JANUARY 1953

Journal

VOL. 45 • NO. 1

AMERICAN WATER WORKS ASSOCIATION

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Journal

AMERICAN WATER WORKS ASSOCIATION

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January 1953
Vol. 45 • No. 1

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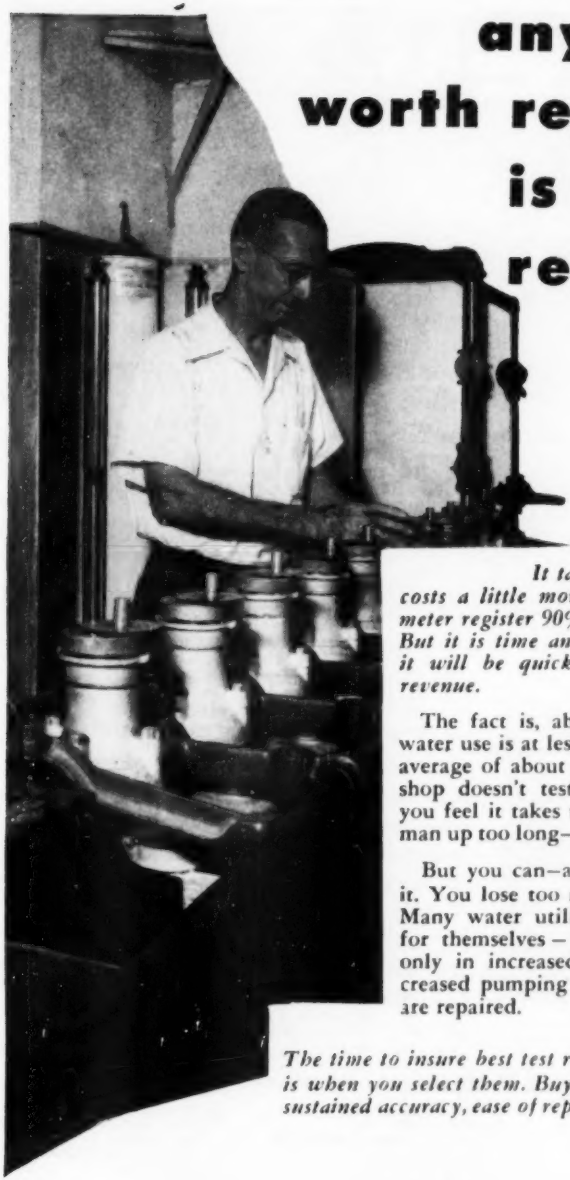

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Feb. 17—New Jersey Section Winter Luncheon, Essex House, Newark. Secretary, C. B. Tygert, Wallace & Tiernan Co., Inc., Box 178, Newark 1, N.J.

Mar. 18–20—Illinois Section at LaSalle Hotel, Chicago. Secretary, J. Leslie Hart, Western Sales Manager, U.S. Pipe & Foundry Co., 122 S. Michigan Ave., Chicago 3, Ill.

Mar. 19—New England Section at Statler Hotel, Boston. Secretary, George G. Bogren, Partner, Weston & Sampson, 14 Beacon St., Boston 8, Mass.

Mar. 23–25—Southeastern Section at Dempsey Hotel, Macon, Ga. Secretary, T. A. Kolb, 89 Alexander St., Charleston, S.C.

Apr. 6–8—Canadian Section at Statler Hotel, Buffalo, N.Y. Secretary, A. E. Berry, Director, Ontario Dept. of Health, Parliament Bldgs., Toronto 8, Ont.

Apr. 16–17—Nebraska Section at Cornhusker Hotel, Lincoln. Secretary, E. Bruce Meier, Asst. Prof. of Civ. Eng., Univ. of Nebraska, Lincoln, Neb.

Apr. 16–17—New York Section at Mark Twain Hotel, Elmira. Secretary, R. K. Blanchard, Vice-Pres. & Engr., Neptune Meter Co., 50 W. 50th St., New York 20, N.Y.

Apr. 16–18—Pacific Northwest Section at Multnomah Hotel, Portland, Ore. Secretary, O. P. Newman, Exec. Vice-Pres., Boise Water Corp., Boise, Idaho.

Apr. 16–18—Arizona Section at San Marcos Hotel, Chandler. Secretary, M. V. Ellis, Supervisor, Sewage Treatment Plant, Phoenix, Ariz.

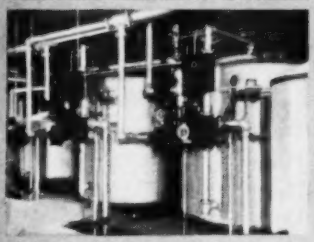
AWWA ANNUAL CONFERENCE

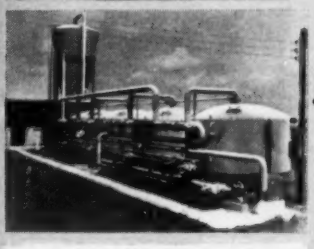
Grand Rapids, Mich. May 10–15, 1953

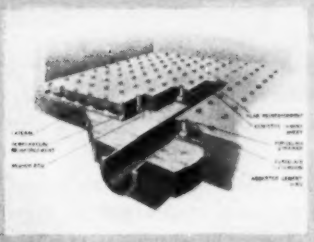
All reservations will be cleared through the AWWA office. The hotels have agreed to accept no reservations for the 1953 Conference except as they are requested on the standard form, through the AWWA.

(Continued on page 10)

4 STEPS TO BETTER WATER







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Coming Meetings

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Apr. 22–24—Kansas Section at Broadview Hotel, Wichita. Secretary, Harry W. Badley, Repr., Neptune Meter Co., 119 W. Cloud, Salina, Kan.

Apr. 24–25—Montana Section at Kalispell Hotel, Kalispell. Secretary, Arthur W. Clarkson, Asst. Director, Div. of San. Eng., State Board of Health, Helena, Mont.

June 17–19—Pennsylvania Section at Hershey Hotel, Hershey. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg, Pa.

June 17—New Jersey Section Summer Outing and Inspection of Johns-Manville Research Center, Finderne. Luncheon at Martinsville Inn, Martinsville. Secretary, C. B. Tygert, Wallace & Tiernan Co., Inc., Box 178, Newark 1, N.J.

OTHER ORGANIZATIONS

Jan. 19—Series of three two-week courses in Radiological Health Protection at Cincinnati, Ohio. Details from Chief, Radiological Health Training Section, Environmental Health Center, 1014 Broadway, Cincinnati 2, Ohio.

Feb. 2–4—Short Course in Industrial Instrumentation at College of Engineering, Univ. of Florida, Gainesville, Fla. Details from Prof. R. C. Specht.

Feb. 2–6—Short Course in Corrosion at Univ. of California, Berkeley, Calif., in cooperation with National Assn. of Corrosion Engineers. Details from University Extension.

Feb. 17–19—American Concrete Inst. at Statler Hotel, Boston, Mass. Details from institute, 18263 W. McNichols Rd., Detroit 19, Mich.

Feb. 19–20—Ohio Water Clinic at Ohio State Univ., Columbus 10, Ohio. Details from Kenneth W. Cosens, Assoc. Prof. of Civil Engineering.

Mar. 16–20—National Assn. of Corrosion Engineers at Chicago, Ill. Details from A. B. Campbell, Executive Secy., 1061 M & M Bldg., Houston 2, Tex.

Mar. 18–20—Short course for water and sewerage personnel at Louisiana State Univ., Baton Rouge. Details from John H. O'Neill, Director, Div. of Public Health Eng., State Dept. of Health, Civil Courts Bldg., New Orleans 7, La.

Mar. 23–27—Western Metal Exposition and Congress, Statler Hotel, Los Angeles, Calif. Details from William H. Eisenman, Secy., American Society for Metals, 7619 Beverly Blvd., Los Angeles, Calif.

Apr. 6–30—Lectures on prestressed concrete, Monday and Thursday evenings at Newark College of Engineering, 367 High St., Newark 2, N.J. Details from Special Courses Div.

Apr. 20–21—Industrial waste disposal regional conference at New Orleans, La. Details from H. M. Conway Jr., Director, Southern Assn. of Science & Industry, 5009 Peachtree Rd., Atlanta, Ga.

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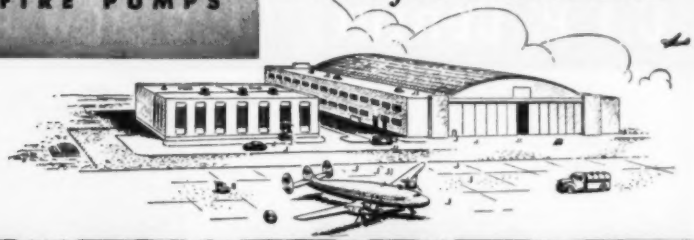
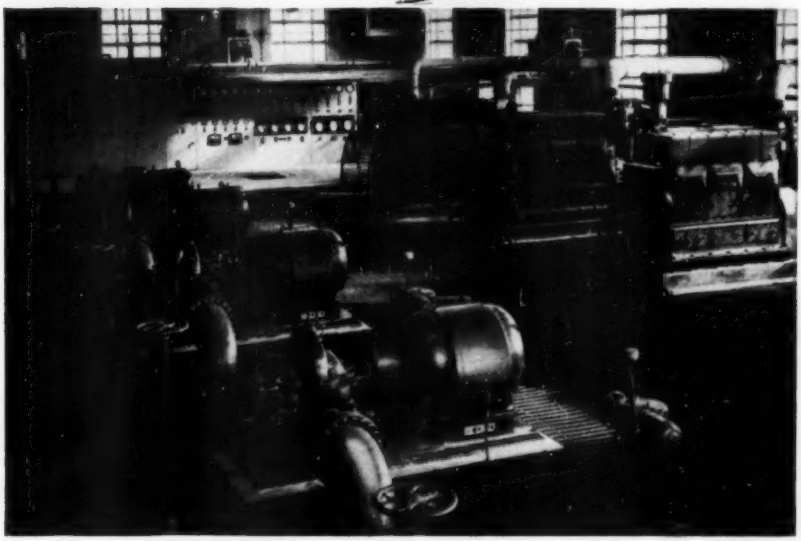
VERTICAL TURBINE PUMPS—WATER TREATMENT

DE LAVAL
FIRE PUMPS

on the job at Idlewild





Ten De Laval centrifugal pumps, with a total capacity of 34,000 gpm, play a vital role in the deluge fire-fighting system of the New York International Airport at Idlewild, Long Island.

The installation is composed of two 2,500 gpm and three 4,000 gpm motor-driven pumps as well as two 2,500 gpm and three 4,000 gpm diesel-driven units, which are used for standby service. When the normal operating pressure drops from 165 psi to 140 psi or less, the electric pumps go to work automatically. The diesels are brought into service as necessary.

Efficient De Laval centrifugal pumps are serving water works and fire-fighting stations all over America. These pumps are available in capacities ranging from less than one million gallons per day to more than 100 million gallons per day.

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THE MEMBERSHIP OF A C.I.P. Century Club now has

96%

OF ALL 6-INCH AND LARGER CAST IRON WATER MAINS EVER LAID IN 25 REPRESENTATIVE CITIES ARE STILL IN SERVICE.

Based on the findings of a survey conducted by leading

CAST IRON

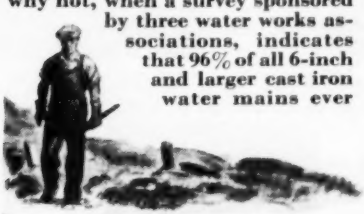
CAST IRON PIPE

DISTINGUISHED CLUB...
43 Members

The Cast Iron Pipe Century Club is probably the most unusual club in the world. Membership is limited to municipal, or privately-owned, water and gas supply systems having cast iron mains in service for a century or more.

Although the Club is formally constituted, there are no dues, no regular meetings, and no obligations other than to inform the Recording Secretary if and when the qualifying water or gas main is taken out of service, or, sold for re-use.

In spite of the unique requirement for membership, the Club roster grows, year by year. And why not, when a survey sponsored by three water works associations, indicates that 96% of all 6-inch and larger cast iron water mains ever



laid in 25 representative cities are still in service. And when answers to a questionnaire, mailed to gas officials in 43 large cities, show that *original* cast iron mains are still in service in 29 of the cities.

If your records show a cast iron main in service, laid a century or more ago, the Club invites you to send for a handsome framed Certificate of Honorary Membership. Address Thomas F. Wolfe, Recording Secretary, Cast Iron Pipe Century Club, Peoples Gas Building, Chicago 3, Illinois.

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SOUTHERN CALIFORNIA SOFTENS WITH
CHEMPRO C-20!

Shown above is the new water softening and filtration plant of the metropolitan water district of Southern California.

The plant, designed to soften Colorado River water for the use of Los Angeles area residents, has a total planned capacity of 400,000,000 gallons of water per day.

Chempro C-20 polystyrene cation exchange resin is the major ion-exchange resin in the softening units.

Other resins developed especially for water treatment include Duolite A-7 (anion exchanger for demineralization) and Duolite A-41 (anion exchanger for silica removal).

WRITE TODAY . . for FREE booklet outlining facilities of Chemical Process Company and list of anion and cation exchange resins available for water treatment.

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With these advantages of Armco Welded Steel Pipe it is easy to select the right diameter and wall thickness for your needs. You can specify heavy walls for severe conditions or lighter walls for ordinary service. And long lengths mean fewer joints. Installation costs are lower.

Use Armco Welded Steel Pipe for water supply and force mains. It offers ample strength and ductility with continued high flow capacity. Write for factual data. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 1173 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation.

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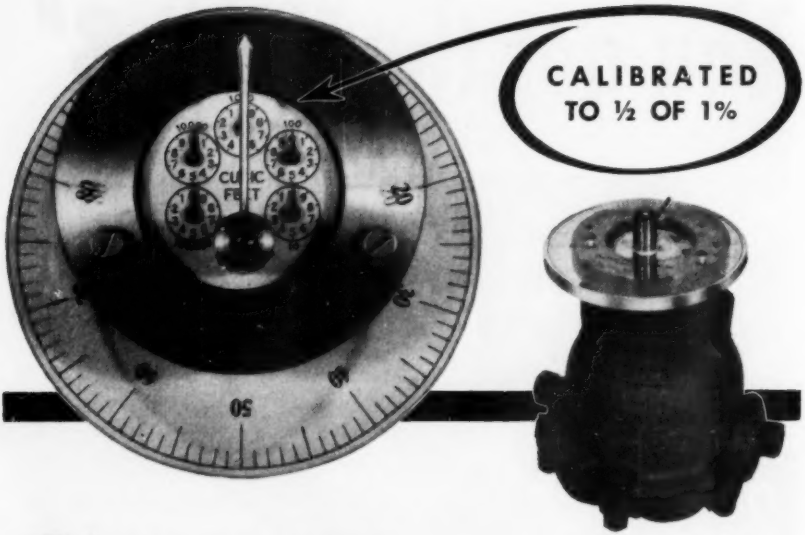
Meets A.W.W.A. Steel Water Pipe Specifications



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For 1" and smaller circular dial meters

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By providing a long test hand over a calibrated transparent plastic dial, the Clearvue Test Dial makes it easy to test meter accuracy at a glance to less than ½ of 1%.

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FREE Complete Ford catalog No. 50 of time and money saving meter equipment.

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Buy the Pipe with the Stripe!
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If you are interested in piping, write today for the **CARLON** "Answer Sheet". It presents concise, factual answers to the 22 most frequently asked questions about **CARLON** plastic pipe—what is it? . . . how is it installed? . . . how does the price compare with other types? . . . what are the recommended pressures and temperatures? . . . etc. In addition, the reverse side covers installation procedure with detailed instructions and photographs.

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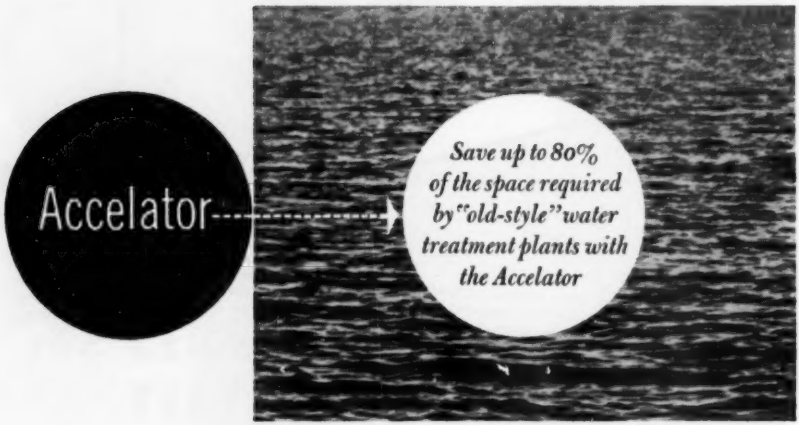

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Proved in over 1,500 installations throughout the world, the space-saving economics of the Accelator is but one of the many advantages thoroughly described by Infilco Bulletin 1825. Write for your copy today.

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HARD DIGGING EASY LAYING

IT TAKES a lot of digging and hard labor to provide a trench for water pipe like the one illustrated. The rock had to be removed, special bedding installed, and backfill carefully selected and handled; a requirement with any kind of water main.

But it takes little time to install "Century" Asbestos-Cement Pipe and Simplex Couplings.

And once installed "Century" Asbestos-Cement Pipe assures full flow area over the years, because it cannot rust and will not tuberculate.

For nearly 40 years Asbestos-Cement pressure pipe has been successfully used as a water carrier and its strength actually increases.

A worthy successor to Gunga Din is "Century" Pipe. We would like to tell you more about it.

Write for FREE BOOKLET, "Mains without Maintenance". Gives valuable data, specifications, and reference material for anyone interested in water main pipes.

Nature made Asbestos . . .
Keasbey & Mattison has made
it serve mankind since 1873

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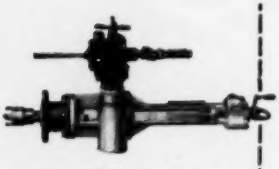

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MUELLER CO. offers you a complete selection of waterworks distribution equipment, supplies and specialties designed and manufactured to high standards of quality and perfection. Write for catalog information on any of these product lines.

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MAIN OFFICE & FACTORY DECATUR, ILLINOIS

Two Eimco Filters in Sewage Plant, Waterbury, Conn. Plant construction directed by H. C. Whitlock, supervised by W. N. Kunsch.

NEW SEWAGE PLANT DEWATERS SLUDGE

—and **Everdur** is chosen for the Eimco Vacuum Filters that do the job

MALCOLM PIRNIE, consulting engineer of New York, designed the sewage plant for Waterbury, Conn. to treat domestic sewage mixed with industrial waste. Vacuum filtration and incineration were advised.

Eimco Corp. supplied two continuous rotary filters with swing agitators. Everdur* was chosen to resist the corrosive sludge effluent. All woven wire screens (5 x 5 mesh x .063" gage), division strips, bolts, nails and screws are Everdur.

Strength, corrosion resistance, good working and welding properties recommend Everdur as a durable alloy. In handling industrial wastes, corrosion problems are complicated. For the proper Everdur Alloy for your application write our Technical Department. The American Brass Co., Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 621-49A

*Reg. U. S. Pat. Off.

specify **EVERDUR**

ANACONDA®
COPPER SILICON ALLOYS

Strong
Weldable
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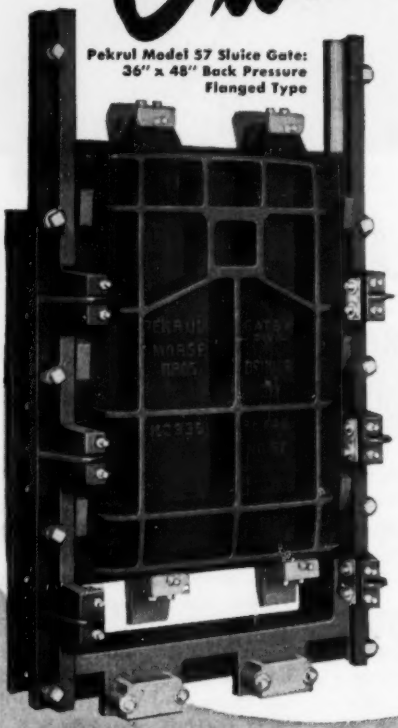
Corrosion-Resistant

Pekrul Gates



Pekrul Model 57 Sluice Gate:
36" x 48" Back Pressure
Flanged Type

PEKRUL GATES are engineered to meet the most rigid requirements for:

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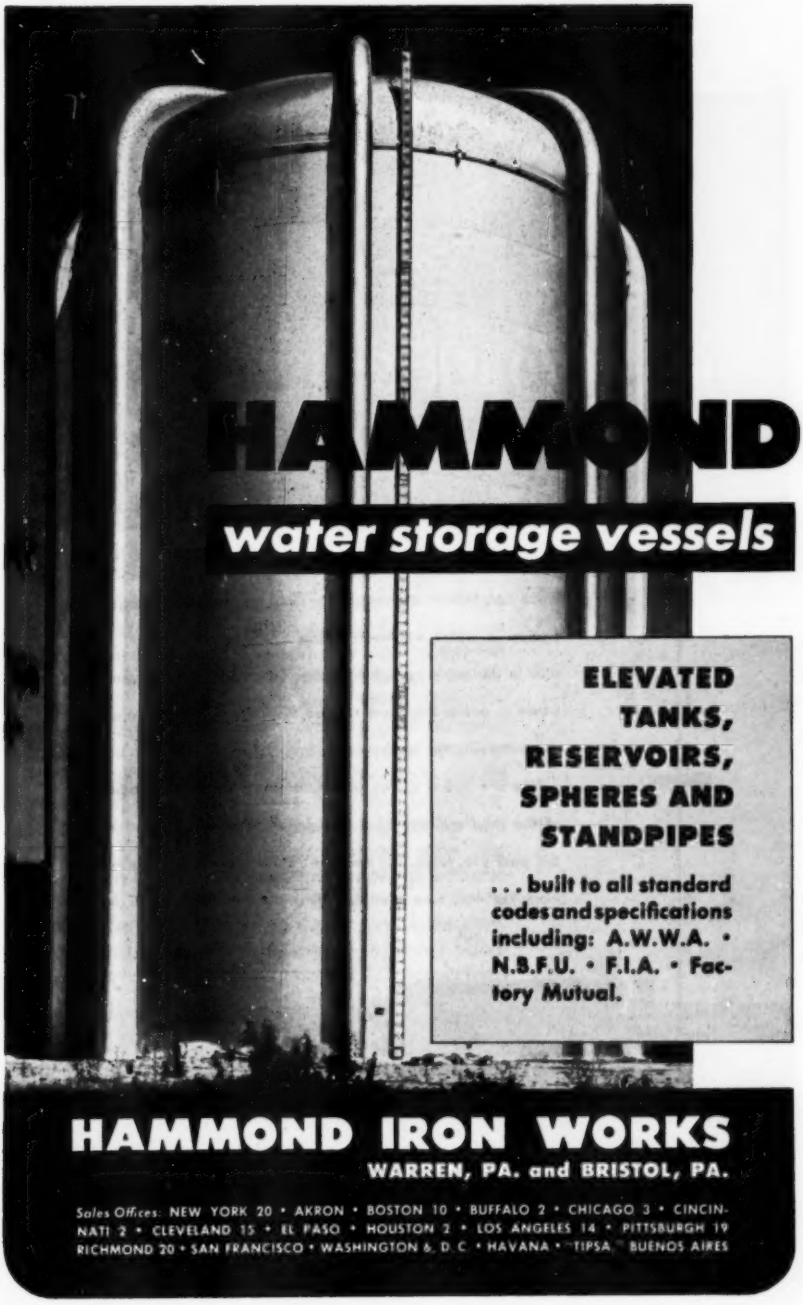
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ELEVATED TANKS, RESERVOIRS, SPHERES AND STANDPIPES
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a report by ROBERTS FILTER

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Since our fiftieth anniversary in 1947, many new Roberts-equipped water treatment plants have been installed . . . and in the same period a number of additions have been made to plants that have carried the Roberts nameplate of dependability for many years.

We are proud of this accomplishment; not only because of the total quantity of a billion gallons a day, added in the past five years, but because of the reports we receive from the men who are operating our equipment year in and year out.

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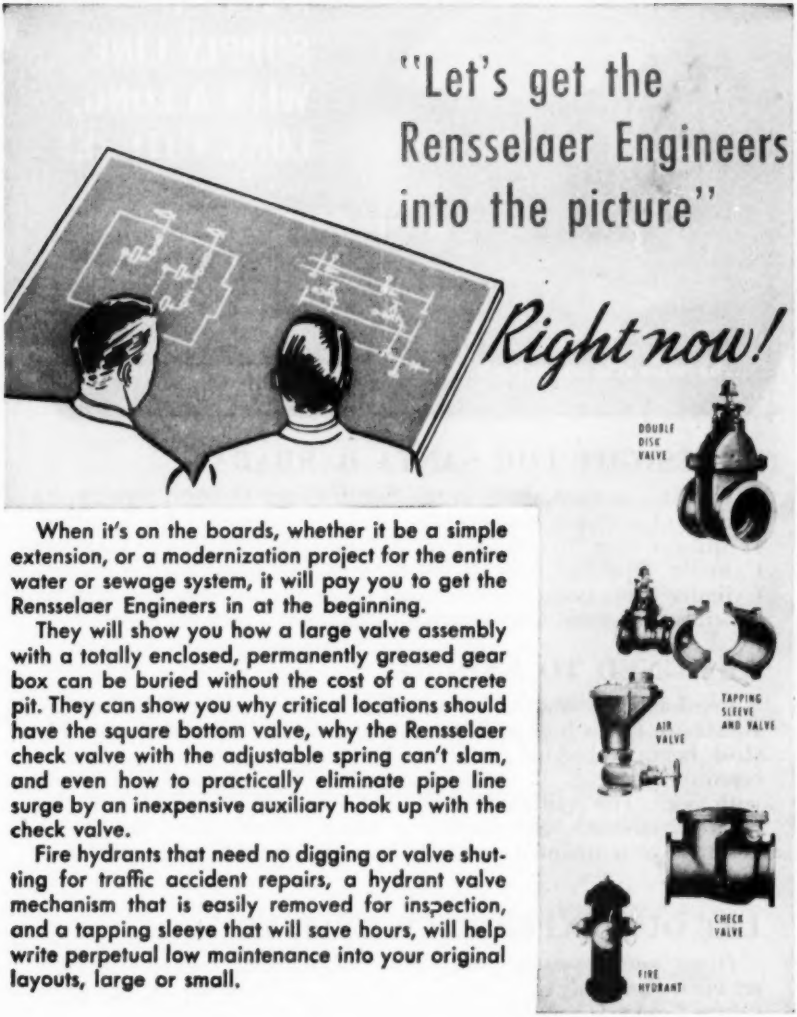

When it's on the boards, whether it be a simple extension, or a modernization project for the entire water or sewage system, it will pay you to get the Rensselaer Engineers in at the beginning.

They will show you how a large valve assembly with a totally enclosed, permanently greased gear box can be buried without the cost of a concrete pit. They can show you why critical locations should have the square bottom valve, why the Rensselaer check valve with the adjustable spring can't slam, and even how to practically eliminate pipe line surge by an inexpensive auxiliary hook up with the check valve.

Fire hydrants that need no digging or valve shutting for traffic accident repairs, a hydrant valve mechanism that is easily removed for inspection, and a tapping sleeve that will save hours, will help write perpetual low maintenance into your original layouts, large or small.

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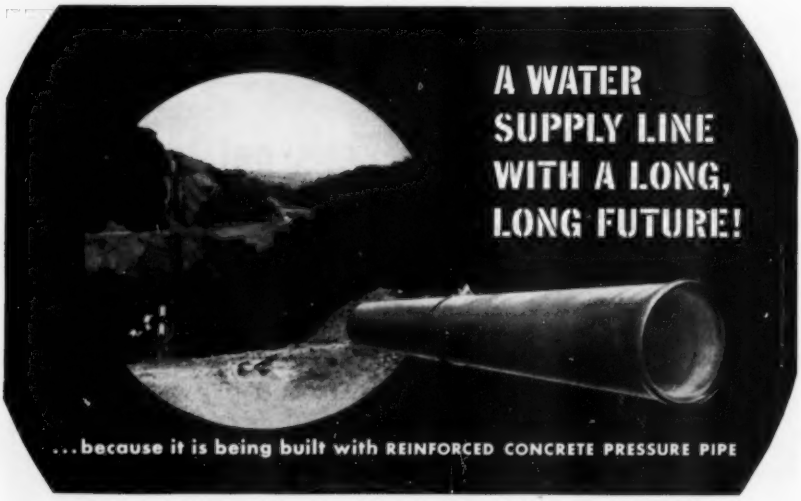

FORESIGHT FOR SANTA BARBARA

The line you see above is the South Coast Conduit near Santa Barbara, California, designed by the U. S. Bureau of Reclamation. It utilizes over 75,000 feet of 27″ and 30″ American Concrete Cylinder Pipe and over 50,000 feet of 48″ Lock Joint Concrete Cylinder Pipe, both manufactured especially for this pipe line by American Pipe and Construction Company.

DESIGNED TO ENDURE

Reinforced Concrete Pressure Pipe, used on this important installation, has a high resistance to corrosion and oxidation. The steel, being embedded in a dense concrete wall, is not exposed to corrosive agencies . . . the concrete actually increases in strength with age. The combination of these two features produces a pipe of great strength and durability which, when placed in service, becomes a permanent installation requiring little or no future servicing.

LET OUR EXPERIENCE HELP YOU

Direct your inquiries to any of our plant offices, and be assured of an immediate reply . . . plus informative bulletins on the type of reinforced concrete pressure pipe that will best meet your needs.

American PIPE AND CONSTRUCTION CO.

Concrete Pipe for Main Water Supply Lines, Storm and Sanitary Sewers, Subaqueous Pipe Lines

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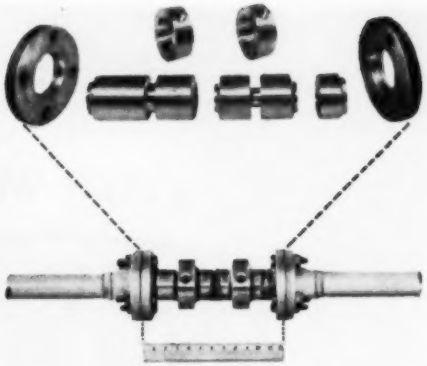
Miniature Venturi Tube Solves Unusual Problem



PROBLEM: Accurate measurement of low flow of a corrosive process liquid through 0.375″ pipe. Fluid under 20 p.s.i. gauge pressure at 50° F., has a specific gravity of 1.32. Maximum flow 158.6 lbs. per hour.

SOLUTION: Ready-made measuring devices were reviewed—advantages and limitations of each type noted. No standard device available to measure low flow accurately under corrosive conditions.

Called in specialist in measuring problems—Simplex sales engineer—and outlined difficult requirements.

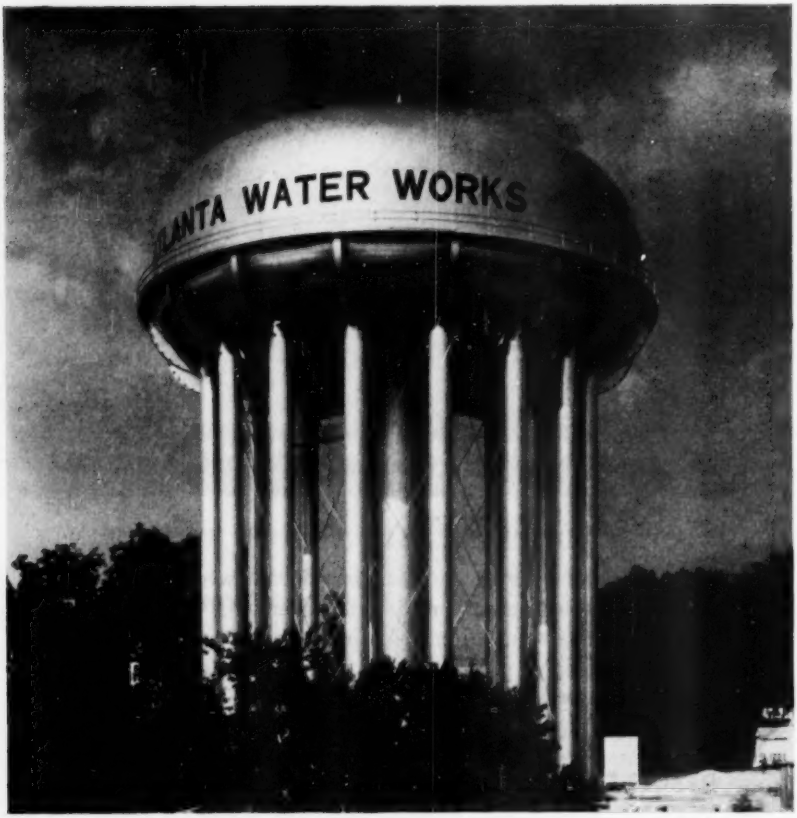
RESULTS: Simplex designed and produced a tailor-made Venturi tube of welded stainless steel that resists corrosion. Interesting device—may well be smallest in industrial process use—throat diameter only .105″. Machining to .0005″ tolerance provides specified accuracy. Unit is simple, reliable, efficient . . . and accurate.

Consult Simplex on measuring devices of unique sizes tailor-made for your special applications, small or large.

For further information write to the Simplex Valve & Meter Company, Dept. 1, 6784 Upland Street, Philadelphia 42, Pa.

SIMPLEX®

VALVE AND METER COMPANY



Horton Tank Cuts Peak Pumping Load

The City of Atlanta, Ga., installed the 2,000,000-gal. radial-cone elevated tank shown above in its water distribution system. Prior to the installation of the tank, high lift pumps in the distribution system were operated at 120 lbs. per sq. in. and pumping rates ranged from 35,000,000 to 105,000,000 gals. per day. With the tank in service, the maximum pumping rate does not go above 85,000,000 gals. per day and the pumping pressure has been reduced to 115 lbs. per sq. in. during the night. Furthermore, the pressure in the mains in the vicinity of the tank now range between 40 and 50 lbs. per sq. in. compared to distribution pressures of 25 to 50 lbs. per sq. in. previously. Write our nearest office for information or estimating figures.

CHICAGO BRIDGE & IRON COMPANY

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In Canada—HORTON STEEL WORKS, LIMITED, FORT ERIE, ONTARIO

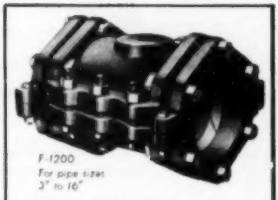
Reinforce all joints subject to vibration with

CLOW

Mechanical Joint BELL SPLIT SLEEVES

When ponderous trucks roar and rumble by, even our finest highways tremble with vibration . . . and so does the water pipe buried below! That's why it's best to play it safe: don't wait for a break; have the foresight to install Clow Mechanical Joint Bell Split Sleeves as *original equipment* wherever the pipe must pass under highway truck routes or under railroad tracks. Specify them for marshland or under water, too—in fact, everywhere that pipe is not readily accessible in case of emergency. They're easy to install . . . no lead, no jute, no caulking!

Write for circular with helpful information and illustrations



F-1200
For pipe sizes
3" to 16"

Use these F-1200 Clow Mechanical Joint Straight Split Sleeves for permanent repairs to pipe barrels. 12" and smaller sizes will repair lengthwise breaks up to 8 inches; 14" and 16" sizes, up to 17 inches.

JAMES B. CLOW & SONS

201-299 North Talman Avenue • Chicago 80, Illinois

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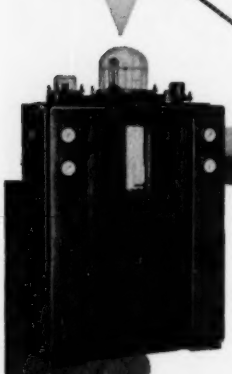

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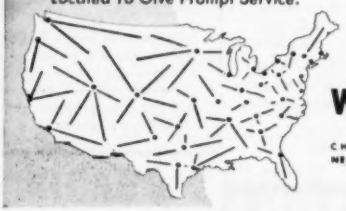

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Management Problems Today

By Louis R. Howson

A paper presented on Nov. 19, 1952, at the Water Works Management Short Course (conducted Nov. 19–21, 1952, by the Business Management Service, College of Commerce and Business, University of Illinois, at Monticello, Ill., and sponsored by the In-Service Training Committee, Illinois Section, AWWA), by Louis R. Howson, Partner, Alvord, Burdick, & Howson, Chicago.

MANAGEMENT in the abstract sense implies control or mastery. As applied to water works, good management is evidenced by the superiority of capacity over requirements, by revenues adequate to provide good service and finance expansion in advance of need, by the equitable apportioning of revenue requirements among those using the service, and by the general satisfaction of the users.

One of the prime attributes of management is timing. Good management anticipates rather than follows needs. Any water works that has not provided for future needs is habitually unable to meet the needs as they mature, whether they be physical or financial.

There are many types of management problems, including:

1. Being alert to the requirements for service, present and future.
2. Interpreting the service requirements in terms of facilities.
3. Assuring that the facilities are available when needed.
4. Carrying forward ordinary operations with economy and satisfaction to the consumers.
5. Anticipating the necessity for replacing property and making the financial arrangements that are required. (It is the author's belief that inasmuch as facilities furnish service, it is property rather than dollars that must be protected by the depreciation reserve.)
6. Raising the funds necessary to provide for the orderly expansion of the property to meet growing needs.
7. Providing revenues adequate to support the property and its services.

The author feels that the greatest single responsibility of management is to assure that its earnings are sufficient

to enable it to supply the best service. As the cost of water service in the average American home is less than 1.5 cents a day per capita, the difference in cost between excellent and mediocre water service rarely exceeds a fraction of a cent per capita per day. This responsibility to assure the best service is shared by regulatory commissions.

Coordination of Activities

Good management, therefore, forecasts its requirements for service, formulates a sound, well-distributed construction program, a sound financial policy, economical administration of operations, and the equitable allocation of revenue requirements through the medium of fair rates. All of these functions must be coordinated to effect a unified, interrelated procedure. Each function has its own problems.

Construction Program

The normal American water utility is a growing institution. The population which it serves rose approximately 35 per cent in the decade 1941–50. Water requirements (127 gpcd in 1945) are usually increasing at a rate of 1–2 gpcd per year.

The cost of supplying water works facilities over the past three decades has increased at least 2.5 times as fast as the population. In 1907 the U.S. census report showed the average book cost of water works to be approximately $30 per capita. Forty years later this figure was approximately $75 per capita. Recent cost-of-reproduction estimates of approximately twenty water plants show an average of 195 per cent of the original costs—that is, the cost of reproducing the average water works in 1952 would be approximately $150 per capita.

As all construction of new facilities must take place in the future, provision for financing must likewise be at future costs. The experience obtained from the Civil War, World War I, and World War II indicates that construction costs will never again be as much as 25 per cent below those of 1952. The *Engineering News Record* Construction Cost Index in October 1952 stood at 588.48 based on 1913 = 100. Cost-of-reproduction estimates indicate that water works construction reflects approximately 85 per cent of the increase in the general construction cost index.

It is part of good management for every water works, large or small, to have its future water requirements studied and its construction programmed and periodically reviewed for at least a decade in advance. If these precautions are taken, it will be practicable to coordinate construction and financing and thus make both much simpler and more economical. Only by advance study and planning can inadequacies and the accompanying consumer dissatisfaction be avoided.

The development of a well-considered construction program usually accomplishes the following:

1. It provides the funds required for construction when needed and not before. In this way it saves the fixed charges on expenditures which otherwise might be made before they are necessary, and eliminates the inadequacies in service resulting from delays in carrying out large expansion programs.

2. Construction and expenditures are made as uniform as practicable. A small expenditure for construction made each year is preferable to accumulated deficiencies corrected at infrequent intervals.

3. The development of such a program minimizes future obsolescence in that each year's construction, in addition to being designed to serve the immediate needs, is planned to fit in with ultimate requirements.

Financial Policies

Many of the problems of water works management are independent of ownership, whether public or private. Other problems, such as means of financing growth requirements and determining rates for service within and outside the city limits, differ appreciably in publicly and privately owned water plants.

Private water works are ordinarily financed approximately two-thirds by funded debt and one-third by equity money. The rates must be adequate to attract the necessary capital from both sources. Practically all private water companies are under the jurisdiction of public utility commissions that operate under statutes which, in general, prescribe that rates shall be sufficient to yield a fair return upon the fair value of the property. This general rule has in recent years been superseded in some states, including Illinois, by a "cost of money" basis. In applying this basis, the original cost of the property is reduced by the net credit balance in the depreciation reserve, the funded debt is deducted, and the balance is taken as representing the equity interest in the property. Upon this equity interest, a rate of return of approximately 10 per cent is considered necessary to attract capital. On this basis, the equity owners get no compensation for the hazard in constructing and operating the two-thirds of the property represented by debt, and the rate base gives no consideration to inflation, the decreased purchasing power of the dollar, the reproduction cost, or the fair value of the property.

The continued application of this procedure, in the author's opinion, will seriously impair the financial credit of the water companies and their ability to provide the facilities which the consumers should have; consequently, the service will deteriorate. The author sees no justification for differentiating between the basis of valuing water works property and other properties with which the water works is competing for its financial requirements. "Fair value" fluctuates with the purchasing value of the dollar whether that dollar be expended in water works or in an office building. Inasmuch as it is a responsibility of management to provide capital for expansion, it follows that it is also its duty to see that earnings are adequate and properly determined in order that continuity of funds is assured.

Municipalities, on the other hand, operate under somewhat different conditions. Municipalities which have owned their water systems for long periods and have wisely managed them are either debt free or have small indebtedness. It is believed that the revenues of such municipal water works essentially consist of the sum of the requirements for operating and maintenance expenses, depreciation reserve, and the average annual needs for additions and betterments. This sum constitutes the amount to be collected from consumers within the city who are the stockholders in the municipal water plant.

The situation for service supplied by municipal plants to consumers located outside the city differs materially. Service to such outside consumers should be strictly on a utility basis. These consumers should pay rates ade-

quate to yield a fair return on the fair value of the property. Under these assumptions, the inside-city consumers get their water substantially at cost, whereas the outside-city consumers pay higher rates in order to yield a fair return on the value of the facilities provided and paid for by others. Recently, in two cities in which inside and outside rates were figured on this basis, the outside rates were approximately 175 per cent of those inside the municipality.

Municipal plants should develop a sound financial policy designed eventually to retire indebtedness and get on a "pay as you go" basis. When this result is accomplished, the revenues collected through rates should be sufficient to pay operating and maintenance expenses; to provide an amount sufficient to cover ordinary additions to the water works such as distribution system extensions and meters; and to furnish an additional amount to cover the average annual requirement for major additions, this sum being apportioned and impounded during the period between such major additions.

Such a policy followed over a long period will result in the cost of water works expansion being approximately 40 per cent less than it would be under debt financing. Costs are amortized as incurred without interest charges.

Financing from revenues in municipal plants has the following advantages:

1. It provides new construction when needed without resorting to bond issues.

2. It avoids possible delays incurred by voting on bond issues.

3. It avoids the political exigencies which arise when bond issues are presented.

4. When such a financial program is properly developed in connection with a comprehensive construction program, the bulges in fixed charges due to bond issues are avoided.

5. The consumer's attention is focused upon service rather than cost, which is the main consideration when bond issues are presented.

6. Financing new construction from revenues reserves to the water department rather than the politician the control of its ability to finance, construct, and maintain high-quality service.

Conclusion

Good management does not just happen. It is created. Conferences in which mutual problems are discussed and experiences exchanged contribute to better management. The better the management, the fewer the problems that recur. Anticipation is superior to correction. The key to good management is planning, coordination, and timely execution of construction, financing, and operating procedures in a manner to meet the approval of the greatest proportion of the water users.

Administration of Small Water Plants

By Wendell R. LaDue

A paper presented on June 18, 1952, at the Pennsylvania Section Meeting, Erie, Pa., by Wendell R. LaDue, Chief Engr. and Supt., Bureau of Water & Sewerage, Akron, Ohio.

WHAT is administration? The words management and administration are synonymous and mean the conducting or carrying on of affairs—of a business, for example. That business can be a water works. An error is frequently made in thinking of the large-plant man and the small-plant man as two different kinds of men. In fact they are not, for they are the same kind of man in constant and daily need of different approaches to the same kinds of problems. Progress in solving the management problems of the small plant cannot be made by driving imaginary wedges between large water utilities and small ones, or by assuming that one is enlightened, well meaning, and knows all the answers, and the other is not and, therefore, must be "managed."

When does a plant cease to be "small" and become "large"? There are now more than 100,000,000 people in organized communities in this country who receive safe and dependable water supplies from publicly and privately owned water utilities. On the average, this service is supplied by one employee for each 1,250 people served. In other words, 80,000 people serve 100,000,000. This is big business, whether a community is served by 5 or 5,000 employees. These 80,000 persons, each possessing an almost infinite variety of skills, training, and talents, every day of the year without ceasing, are contributing unselfishly and selflessly of their energy, ability, and ingenuity to the biggest business, in tonnage, in the United States. There is no precise or scientific way by which the achievement or contribution of each can be measured. But this is not important. It is necessary, though, that the water works profession foster among its members a broad and sympathetic understanding of the mutual responsibilities and problems of small and large plants. Such an understanding among water works men will result in greater encouragement from the public.

Is there a truly impartial viewpoint? Once a fine old Confederate gentleman displayed wonderful honesty and candor when he wrote a book entitled: *An Unbiased History of the War Between the States—From the Southern Point of View.* It is not the author's purpose or intent to discuss that all-important phase of management, public relations, but it is difficult to omit it. Any public relations department would be wise to display the lines which Dickens once gave to one of his characters, Martin Chuzzlewit: "What we've got to do is to keep up our spirits and be neigh-

borly. We shall come out all right in the end, never fear." This is truly a great goal for all water utilities, large or small. A great amount of lasting good can be accomplished by a kind word, a courteous gesture, or the moment or two necessary to consider the other fellow's problem. To the "other fellow" *you* are the "other fellow."

Why should the water works industry improve its administration? Good management is the result of a combination of continuing policies, including expansion of both facilities and operations, sound financing, efficient conduct of business, and satisfying services. Good management is as essential for small plants as it is for large water works systems. All too often management is considered to be confined to the direction of more or less routine operating functions. In a practical sense, it must include sound planning for the future and the coordination of needs, plans, and accomplishments with the financial obligation and ability of the community to support them.

Water Works Administration Committee

The water works profession will accomplish much to improve its own status if it can produce an enlightened and progressive top management. The purpose of the American Water Works Association's Committee on Water Works Administration is to do just that, as illustrated by the purposes of its various subcommittees:

Constitutional and Statutory Aspects of Municipal Water Works Organization—charged with the duty of studying existing state and province laws and municipal ordinances, and formulating principles relating to types of municipal water works organizations.

Radio and Mobile Communication Facilities for Water Works—charged with the study of the use of radio and mobile communication facilities available for water works, together with the collection of data on the use of radio in the water works field. The committee has a continuing interest in federal activities affecting wave allocation to utilities.

Water Used in Air Conditioning and Other Refrigeration—charged with the study of the problems arising from the use of water in air conditioning and other refrigeration and to recommend policies as they affect water works (and sewage) facilities.

Water Use in Fire Prevention and Protection—charged with the study and evaluation of methods of fire prevention and protection and of protecting sprinkler systems from freezing. This committee may be expanded to meet the pressing problem of renegotiation of insurance contracts to meet the demand sensed in increased costs of replacement.

Public and Worker Relationships—charged with: [1] considering and proposing to the Board of Directors activities on behalf of the Association in the field of public relations; [2] the production of guidance material in the field of public relations; and [3] the review of material which is in process of production by the Association.

Compensation of Water Works Personnel—charged with the gathering of comparative material and data and the formulating of a general schedule of compensation for water works personnel and management.

Pension and Retirement Plans—charged with the duty of collecting information upon, and promoting the adoption of, pension and retirement

plans in the public water works industry, as well as the study of developments in the industrial field and their effects upon public employees.

Safety Practices—charged with the preliminary study of personnel safety and working conditions in plant facilities and physical structures. This study may be extended later to the border field of public safety in water utility construction work. This particular field of management is attracting nation-wide attention.

Taxation and Revenue Allocation—charged with the assembly and study of data on the taxation of water works systems and the diversion of funds from the water works utility to other activities, and the formulation and distribution of basic principles of good management of taxation and revenue allocation.

Water Main Extension Policy—charged with the study of the problems involved in the extension of water mains, both within and without the corporation limits, including a digest of enabling legislation.

Water Department Reports—charged with the review of existing annual reports of water works organizations and the preparation of recommendations on content and style of annual reports.

Water Rate Schedules—charged with the consideration of the fundamentals of water rate structures and the outlining of the policies upon which rate schedules may be developed in order to distribute equitably the funding, operating, and maintaining of water works utilities.

Water Use—charged with the collection and evaluation of data on:

1. Industrial water use, encompassing the water requirements of specific industrial operations and involving the collection of information from units in the same industry over a wide geographic area, in order that water requirements per unit of product may be tabulated.

2. Domestic water use, encompassing the collection of data from a number of water utilities from which a breakdown is available to show per capita water use in different types and sizes of residences and various classes of commercial establishments.

Forms of Management

Is it not possible that these problems of administration result from the inadequate attention that is given to the fundamental reasons for their occurrence? Does not water works management spend its time discussing the results of inadequate management, whereas it ought to be doing something about analyzing the causes, diagnosing the resulting weaknesses, and then taking the steps necessary to correct them? Realizing the impractical multiplicity of state laws, local ordinances and charters, is this truly not a challenging problem? At the very outset, water works men themselves become quite philosophical and altruistic in realizing and appreciating the other fellow's position. The ramifications are many but the generalities few.

There are many cities in which the water works management is directly under the city council, the personnel of which, by nature, is continually shifting. In such a setup, centralized top responsibility is generally slight, as there is no real concern about long-range planning for the work of later administrations. There are very often too many potential "bosses," and the superintendent, no matter how effi-

cient, may be subject to change with the city administration.

Water works management under the city manager form of government is only as good as the city manager, who, in turn, is subject to the changes and whims of a council or other elected board of similar nature. When a city manager is changed, his appointees usually go with him.

A third general form of top management is that of the special water works commission, usually consisting of three to five men with overlapping terms of such lengths that, in general, no one political administration can upset the board by a majority of new appointments. Such a board is responsible to no one but the public which it serves. It is nonpolitical; its continuity is assured and it attracts to its membership the best qualified men of the community. This form of management lends itself to a continuity of employment of water works personnel; the maintenance of high efficiency; the establishment of constructive, continuing policies on construction, operation, and rate stability; and the furnishing to the consumer of a maximum of satisfying service at a minimum of justifiable expense and cost.

In all local organizations, management is brought face to face with one of the most baffling challenges of human nature and behavior: "People get and do what they want, good or bad." When a superintendent in the near-perfect protection of an ideal, commission-operated water works asks why a certain city countenances the shortcomings of some council-controlled operation, the only answer forthcoming may be "Because they (the people) want it and like it that way." For this reason, regardless of its logic, a uniform type of top management is not always potentially possible or perhaps even actually desirable. Past history and local conditions will weigh heavily and must be considered.

Legislation

It appears quite evident that practically every undertaking of a water department is connected in some way with the basic and enabling legislation applicable to the actual organization of any department in any particular state. Water works management must be continually aware of this constantly changing legislation. Pennsylvania affords an outstanding example of this observation. Under the "Authorities Act" of 1935, 71 water works management and ownership groups were functioning in 1950.

The series of legislative enactments known as the "authority acts" permits the citizens of a single city or town or of groups of incorporated and unincorporated places to establish an agency through which governmental units may provide needed facilities and services for themselves, upon a self-liquidating basis, in the manner of private industry and without obligating the pre-existing units of government. Such an authority is authorized to file liens for debts owed, is given the power of eminent domain (but not the power to acquire a water works or other system by condemnation), can sue and be sued, and can issue revenue bonds, but may not obligate the municipality. The life of an authority under the Pennsylvania acts is limited to 50 years, whereas bond issues are limited to 40 years and the maturity of refunding bonds is restricted to the life of

the authority. At the termination of the life of an authority, its property may revert to the municipality or municipalities which incorporated it. One further stipulation, which is of great value, requires that for the period during which authority revenue bonds are outstanding, an engineer must be retained by the authority to advise it on matters of planning and management.

Authorities have been given the power to assess benefited properties for the cost of improvements in proportion to the benefits received, giving them, in this respect, an advantage over private companies which must establish a rate structure that will make them entirely self-supporting from revenues or rentals. Private companies are permitted no other sources of income and may not be parasites on any municipal funds, except, possibly, when a system is leased to the municipality for operation. On the other hand, authorities cannot be deprived of their revenues to carry out other municipal functions.

The populations served by various Pennsylvania water authorities in 1950 varied from 700 to more than 100,000. By the end of 1947, 65 water authorities served more than 1,300,000 consumers and the total assets of the group were in excess of $101,250,000.

Conclusion

The procedures discussed support the idea that there is no real difference in the objectives of the "large" and the "small" plant. The author gives well-deserved praise to the small operator. He has sometimes been compared to a one-man ball team. Just as busy, he pitches the ball, runs behind the plate to catch it, and, if it is hit, he runs to the outfield to catch it, or attempts to put out the runner, all by himself. In other words, he treats the water, operates the plant, distributes the water, reads the meters, bills the customers, and collects the money, all with the utmost confidence that things will "come out all right in the end." The large-plant operator may be compared to the president of the league, but he has no more fun, nor do his customers have more confidence in him than in the small operator. The author knows no other career that affords a greater sense of inner satisfaction to those who embrace it successfully nor another business in which there is greater determination to do a better job.

Red Water and Its Prevention

By Philip S. Davy

A paper presented on Sept. 17, 1952, at the Wisconsin Section Meeting, Madison, Wis., by Philip S. Davy, Vice Pres., Davy Engineering Co., La Crosse, Wis.

RED water is a serious problem to the water works industry and its consumers in many communities in Wisconsin and other states. A number of solutions to the problem have been tried in many locations with varying degrees of success. A great deal of time and research has been spent on solving the problem but there has been little effort to coordinate the results of the studies made.

The author's experience indicates that there are at least three distinct sources of the red water problem and unless all three are taken into consideration, it is probable that treatment will be only partially successful. Red water is basically caused by one or more of the following factors and frequently by all three: [1] presence of iron or manganese or both in the raw water; [2] a corrosive water supply; and [3] growth of iron bacteria in the distribution system.

Many of the methods of treatment advocated for correction of red water conditions specialize in correcting only one of these conditions; thus, when two or more conditions exist, results cannot be expected to be completely satisfactory. This concentration on one aspect of the problem has resulted because most experimentation has been performed by manufacturers whose basic intention was selling their product. One of the functions of a consulting engineer is to provide the service necessary to coordinate these various approaches and recommend the best methods for the problem under study.

Iron and Manganese

Many municipal water works have excessive quantities of iron or manganese or both in their raw-water supply. Sometimes proprietary chemical compounds, such as the various forms of phosphates, can prevent the deposition of iron or manganese in the distribution system. The reasonable cost of such compounds justifies consideration of this approach. The author's experience indicates that when more than 0.3 ppm of combined iron and manganese is present, the most generally applicable method is removal. This upper limit of 0.3 ppm has been recommended by the U.S. Public Health Service and the Wisconsin State Board of Health and is generally accepted by most state boards of health.

When the supply contains iron or manganese in excessive quantities, the problem of red water will occur throughout the system, although it may be worse in dead ends or areas of little circulation. The increase in the red water problem in dead ends is due to two other factors which will be discussed.

There are a number of basic methods of removal. The principal ones include aeration followed by coagulation and filtration, pressure aeration and filtration, and iron and manganese removal by cation exchange.

Aeration, Coagulation, and Filtration

Aeration followed by coagulation and filtration is usually classified as an open process—for example, a deep well supply pumped to surface treatment facilities followed by booster pumping to the city mains. This process can be combined readily with lime-soda ash softening. Because of the relatively high costs of construction and the high degree of operative skill required, this procedure is, in general, more applicable to large communities having a centrally located source of supply.

Pressure Aeration and Filtration

In the past 15 years, the pressure aeration and filtration method of treatment has become highly developed. The cost of operation is negligible and the cost of construction is low. When deep wells constitute the supply, direct pumpage through a pressure tank arrangement is simple and effective. No surface storage reservoirs nor booster pumps are required. In general, both iron and manganese are present in soluble form in raw water. Each part per million of iron present as Fe requires 0.07 cu ft of free air at 80°F to oxidize to iron oxide, which will re-

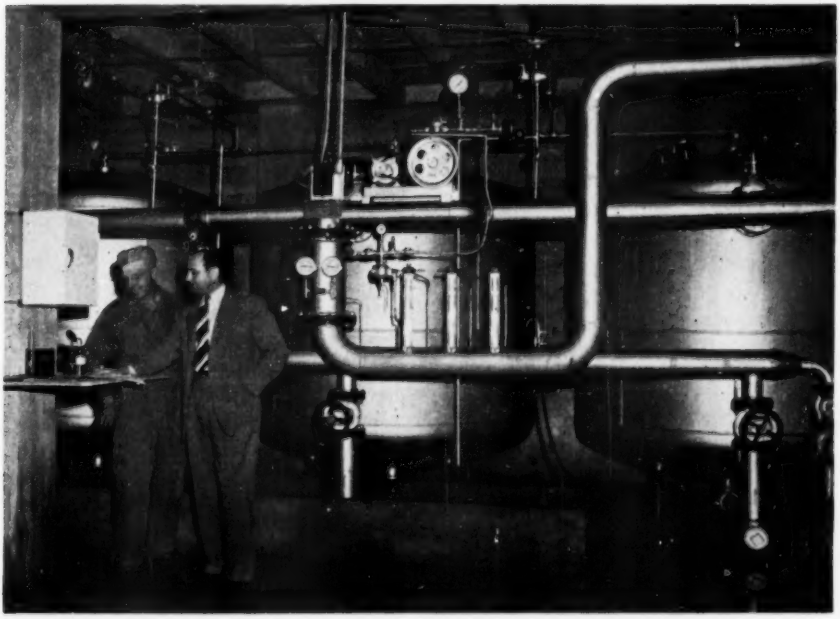


Fig. 1. Pressure Aeration and Filtration Unit at Alma, Wis.

Practically all iron-bearing waters will be reduced to 0.2 ppm of iron or less by pressure aeration and filtration treatment.

main on the surface of a sand or anthracite filter where it can be removed by backwashing. Although the method of adding air is important in order to secure complete oxidation, such minute quantities are necessary that primary attention must be paid to avoiding excess air entrainment. A serious "white water" problem can be developed if more air goes into solution than will remain dissolved at the highest temperature and lowest pressure at which water is delivered (atmospheric pressure and 80°F were used in the author's study). As an indication of the small quantities of air required, a 450-gpm pump would require a ½-hp air compressor.

TABLE 1

Chemical Characteristics of Alma, Wis., Water

Chemical Characteristic	Raw Water	Plant Effluent
Total hardness—*ppm*	260	260
Methyl orange alkalinity—*ppm*	256	286
Free carbon dioxide—*ppm*	21	
Iron—*ppm*	0.8	0.2

In general, pressure filters for this type of treatment operate at 2.5–3 gpm per square foot of bed area and backwash at 15–20 gpm per square foot of bed area. Practically all iron-bearing waters will be reduced to 0.2 ppm of iron or less by this type of treatment.

The effectiveness of removal using this type of equipment has been illustrated at Alma, Wis. The chemical characteristics of the raw water and the plant effluent are given in Table 1, and the pressure aeration and filtration unit is shown in Fig. 1.

Without treatment other than aeration followed by coagulation and filtration or pressure aeration and filtration, treated water will revert to a high-iron water in the dead ends very rapidly. When manganese is encountered alone or as a major item in conjunction with iron, care must be taken, as manganese is not oxidized to a nonsoluble floc as readily as iron. Field tests will indicate whether detention or pH adjustment before filtration is needed. It should also be noted that the addition of oxygen will increase the corrosivity of the water.

Cation Exchange

Cation-exchange compounds have the capability of exchanging the sodium available in the compound for calcium and magnesium. It is less well known that cation-exchange compounds will also exchange sodium for iron or manganese or both in the raw water supply. The process normally used results in a soft water having a combined iron and manganese content of less than 0.2 ppm. Salt is used as the regenerant.

When softening and iron removal have been used in combination a number of failures have occurred. In every failure, however, the problems that arose could have been easily avoided. Some of the problems are presented and their solutions discussed in succeeding portions of this paper.

In removing iron or manganese by cation exchange, care must be taken to keep introduction of air into the water at a minimum or the insoluble oxides will be filtered out by the cation-exchange compound. The usual plant arrangement allows some oxidation even though efforts are made to avoid it. The deposition of oxides will gradually clog the bed and destroy its usefulness. It is necessary, therefore, to select a cation-exchange compound of the carbonaceous or synthetic-resin type as these compounds can be readily cleaned with acid when necessary.

Softening of the water will increase its corrosivity, a point which will be discussed in greater detail. Manual regeneration by plant operators is often inconsistent and frequently gives poor results. Automatic regeneration is simple and economical and can be provided at reasonable cost.

1.0 ppm and the supply is hard, as blending untreated with treated water can provide a finished water of less than 0.3 ppm iron and manganese. Two alternatives are available for other waters.

The hardness, iron, and manganese can be removed from most of the sup-

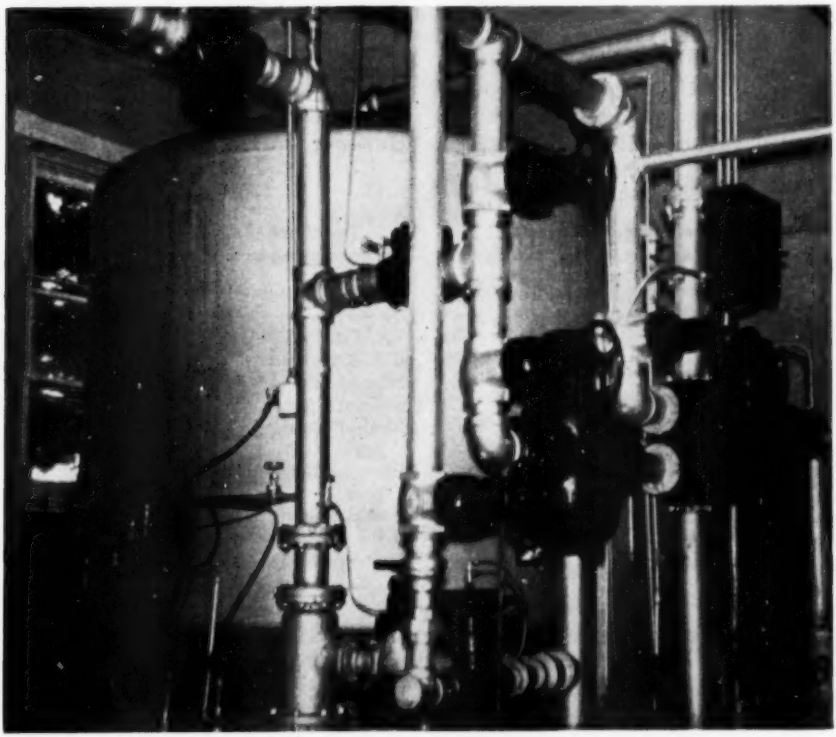


Fig. 2. Cation Exchanger Unit at Blair, Wis.
Zero-hardness water is used at Blair without difficulty.

One problem that arises when softening and iron removal are used in conjunction is the need to bypass part of the raw water if a hardness of 70–85 ppm is desired in the distribution system. This problem can be solved simply if the combined iron and manganese content is less than approximately

ply and an iron removal plant of the pressure aeration and filtration type can be used on the bypass. Thus, a water low in iron and manganese and having an adjustable hardness can be provided readily.

The second alternative is to soften the entire supply to zero hardness.

Many statements on the impracticability of obtaining zero-hardness water, despite its known advantages, have been made. If the corrosive tendencies of soft water are corrected, zero-hardness water is quite practicable. A number of cities and villages in Wisconsin have utilized zero-hardness water for from 2 to 15 years without difficulty. Among these are Colby, Arcadia, Blair (see Fig. 2) and Eleva.

Iron and manganese removal by cation exchange is simple and economical. Rates of application can reach 7 gpm per square foot, space is saved, and backwash requirements are generally the same as application rates. Salt efficiencies of the new resins have become surprisingly high compared with those of precipitated synthetics and greensands. Salt guarantees as low as 0.25 lb of salt per approximately 17,000 ppm of hardness removed have recently been offered. When the salt costs $12.00 per ton and the water contains 340 ppm of hardness, the cost of the salt to soften 1,000 gal to zero hardness will be 3 cents. The effectiveness of this type of treatment is illustrated by analyses of Eleva and Arcadia, Wis. waters (Tables 2 and 3).

TABLE 2

Analyses of Eleva, Wis., Water

Chemical Characteristic	Raw Water	Treated Water
Total hardness—*ppm*	58.0	0.0
Calcium—*ppm*	34.0	0.0
Magnesium—*ppm*	24.0	0.0
Sodium—*ppm*		
Methyl orange alkalinity—*ppm*	47.0	47.0
Free carbon dioxide—*ppm*	15.0	15.0
pH	6.0	6.0
Iron—*ppm*	6.8	0.0
Manganese—*ppm*	0.25	0.0

The pH of the Arcadia, Wis., water was adjusted at a point beyond the sampling cock where the analysis was collected. If the water were discharged at the pH values given in Table 3, the iron would increase rapidly. The pH of the Arcadia plant effluent was raised by the addition of sodium hydroxide. This treatment may not always be sufficient.

Corrosivity

Many of the ground water supplies in Wisconsin and adjoining states are corrosive in varying degrees. The water is frequently corrosive even when only trace amounts of iron and manganese are present and is almost invariably corrosive when appreciable amounts exist, because these minerals were introduced into the ground water supply largely by contact with a corrosive water. Experience in Wisconsin indicates that the principal source of corrosion in natural underground waters is the presence of free carbon dioxide in the water. When ground waters pass through magnesium or lime deposits, free carbon dioxide is converted to bicarbonate hardness in

TABLE 3

Analyses of Arcadia, Wis., Water

Chemical Characteristic	Raw Water	Plant Effluent
Total hardness—*ppm*	221	3.0
Calcium—*ppm*	145	0.0
Magnesium—*ppm*	76	3.0
Sodium—*ppm*	5	255.0
Methyl orange alkalinity—*ppm*	205	234.0
Phenolphthalein alkalinity—*ppm*	0	11.0
Free carbon dioxide—*ppm*	9	0.0
pH	7.6	8.9
Iron—*ppm*	3.1	0.1

varying degrees. Thus, hard waters are less likely to be corrosive.

Expressed in another way, adjustment with lime or sodium hydroxide to a pH of 8.2–8.4 (8.2 is the point at which free carbon dioxide can no longer exist in the water) usually results in elimination, for all practical purposes, of iron pickup in the distribution system. Corrosion is one of the three primary causes of red water in a distribution system and can create a serious red water situation even when there is little or no iron in the supply. The problem is primarily concentrated in dead ends or areas where there is little circulation of water. Under these conditions, the iron content of the water will increase rapidly even though a low iron water is delivered to the system. The corrosion problem cannot be separated completely from the discussion of iron bacteria that follows and it is difficult to be sure just what percentage of the difficulty is due to corrosion and what percentage to iron bacteria. Iron pickup due to corrosion is quite rapid, and a period of weeks is sufficient to create a problem.

TABLE 4

Analyses of Independence, Wis., Water After pH Adjustment Discontinued

Chemical Characteristic	pH Adjustment Stopped	6 Weeks After pH Adjustment Stopped
Total hardness—*ppm*	123	123
Methyl orange alkalinity—*ppm*	110	110
Free carbon dioxide—*ppm*	19	14
Iron—*ppm*	0.1	15.1
Manganese—*ppm*	0.25	0.25
pH	6.85	7.05

Independence, Wis., has an iron removal plant that reduces the iron to less than 0.2 ppm. Because of changes in operators, pH adjustment was discontinued. The analyses at a 6-in. dead end, 2,600 ft long, for a six-week period are given in Table 4. The iron content increased so markedly that the water could not be used for washing and was hardly usable for drinking. There are many similar instances of a low-iron content water being pumped into the system and a high-iron content water being found on dead ends. These occurrences are seldom as extreme as the Independence, Wis., incident, however. Cuba City, Wis., represents a typical condition (Table 5).

TABLE 5

Analyses of Cuba City, Wis., Water

Chemical Characteristic	Raw Water	Water in Dead End
Total hardness—*ppm*	312	312
Methyl orange alkalinity—*ppm*	295	295
Free carbon dioxide—*ppm*	37	37
Iron—*ppm*	0.1	2.6
pH	7.2	7.2

The manufacturers of proprietary chemical compounds containing phosphates can produce results clearly indicating that this family of chemicals will eliminate red water caused by corrosion. To date the author's results using these materials have not been as satisfactory as pH correction. When it is realized that the primary area to be controlled is the dead ends rather than the main system, the difficulty in the use of the phosphate family can be recognized. The author's experience indicates that threshold treatment with these compounds depends, at least in part, on the building up of a protective film on the metal surface rather

than on the concentration present in the water in contact with that surface. Because of the low velocities in a dead end, the protective film does not deposit where required but in the main distribution system where turbulent flow exists. Regular flushing of the dead ends would probably correct this condition but necessitates the waste of large quantities of water and is difficult to maintain systematically because of the press of other duties on the operator. Because phosphates are an excellent food source for iron bacteria and are quite likely to stimulate their growth, a low rate of chlorination is desirable as an adiunct to phosphate stabilization.

The author's experience with pH adjustment has been limited to lime or caustic soda (sodium hydroxide), although soda ash could also be used. In reasonably hard waters (170 ppm or more), lime has the disadvantage of tending to precipitate part of the hardness, thus creating a scale problem. Also, it must be fed as a slurry, which requires a more expensive feeder. In addition, the feed lines are subject to clogging. Lime, of course, increases the hardness of softer waters. Sodium hydroxide forms a true solution and consequently can be readily added to water with a standard liquid feeder. The only disadvantage lies in the cost of sodium hydroxide. Cost is not a major problem for small communities as water quantities requiring treatment are not great. The cost at the present time is $6.20 per 100 lb in 400-lb drums. It requires approximately 1 ppm of caustic soda to neutralize 1 ppm of free carbon dioxide. Therefore, it would cost $0.90 per million gallons of water containing 17 ppm of carbon dioxide. It is desirable, when the pumping arrangement makes it economical, to utilize open aeration to release part of the carbon dioxide.

A question may arise about the usefulness of the Langelier index or the calcium carbonate saturation index for predicting red water problems from a new supply source. The author has found that the application of these indexes to cold water in distribution systems does not always clearly indicate a corrosive water even though actual use may indicate that iron pickup has resulted from corrosion. Table 6 gives the Langelier index for four towns, all the waters of which were subject to iron pickup in dead ends, although in three of the towns, the Langelier index is so slightly negative that it would be difficult to predict results.

TABLE 6

Langelier Index of Various Waters

Water Sample	Index at 60°F
Rushford, Minn.	−0.08
New Auburn, Wis.	−3.15
Independence, Wis.	−0.56
Cuba City, Wis.	−0.10

Caution is necessary, as iron pickup is seldom separate from the iron bacteria problem and both should be investigated.

Iron Bacteria

There is some question whether the organisms causing red water problems are bacteria. Some of these organisms may be more closely related to algae.

There is no question that a problem is created, however. In the first problem discussed herein, iron was present in the water source itself. As a result, fixture staining is almost universal throughout the system although it may be more acute in noncirculating sections (dead ends). When there is iron pickup due to corrosion, some prob-

lem may exist throughout the system with a definite increase in dead ends. When iron bacteria is the cause of red water, the problem is normally concentrated in the dead ends or areas of little circulation. Actually the three problems cannot be separated and even though the first, iron in the raw water, does not exist or is nominal in amount, corrosion and iron bacteria usually occur simultaneously.

Red water complaints usually arise in areas of little circulation. In these areas, hydrant flushings are initially deep red or brown, and bacteriological smears usually indicate the presence of sulfate-reducing or iron-consuming bacteria. The sulfate-reducing bacteria fall into the general classification of *Desulfuricans*. These bacteria reduce the sulfates in the water to hydrogen sulfide which attacks the pipe, dissolving the iron and placing it in solution in the water. This reaction frequently results in a hydrogen sulfide (rotten egg) odor in the water in dead ends as well as a red water problem, even though the raw water does not contain appreciable amounts of hydrogen sulfide. The iron-consuming bacteria, such as *Crenothrix, Leptothrix* and *Coccobacillus,* seem to require iron already in solution in the water and do not seem to utilize iron from the pipe as a food source. Pitting of iron pipe will occur, however, when these bacteria are present in quantity. In addition, by growing in great numbers and concentrating the iron already available, they create a red water problem equivalent to that caused by iron in the raw water as the bacteria are swept into consumers' services by occasional surges of water. These bacteria are present in most ground waters in Wisconsin, and require only conditions favorable to growth to multiply and cause trouble. Favorable conditions are encountered in water works system dead ends particularly where iron is available in the water for food.

The logical agent for control is chlorine although chloramine treatment is also effective. The author feels that continuous dosage similar to that for killing pathogenic bacteria for public health purposes is not always required. Three methods in conjunction with pH correction have been tried. When the regular use of chlorine is not desired, annual massive chlorine doses may be used. The multiplication of iron bacteria appears to be slow. If iron pickup due to corrosion is controlled, a period of a year or more can elapse before iron bacteria create a red water problem. A massive chlorine dose over a 24-hour period, and a thorough flushing of the system will restore the water to a satisfactory condition. This method has been effective at Independence, Wis., for a number of years.

TABLE 7

Effect of Massive Chlorine Doses on Rushford, Minn., Water

Chemical Characteristic	Raw Water	Dead End	
		Normal	Chlorinated and Flushed
Total hardness—*ppm*	330	330	330
Iron—*ppm*	0.4	3.3	0.4
Manganese—*ppm*	0.02	0.02	0.02
Free carbon dioxide—*ppm*	17	17	17

Attempts are being made to correct the water at Rushford, Minn. During the field studies to determine the source of difficulty at Rushford, massive chlorine doses—approximately 25 ppm residual—were used. The analy-

ses given in Table 7 show the improvement obtained. The improvement is due to chlorine kill of iron bacteria plus replacement of stagnant water in the dead ends with fresh water by the heavy flushing required. It is anticipated that water in the dead ends will revert to a high-iron content within two to three months.

A softening plant is being installed in Rushford. In addition, both a caustic feeder for pH control and a hypochlorite feeder for iron bacteria control will be utilized. Chlorine and caustic will both be added at the softener discharge. It is the author's opinion that a low rate of application of chlorine—approximately 0.5 ppm at the plant—will control iron bacteria growth provided that a massive dose over a 24-hour period is used to kill the established flora. Regular low-rate chlorine feed may be applied on the plant discharge.

Summary

There are three aspects to be considered in dealing with the red water problem: [1] presence of iron or manganese or both in the raw water; [2] corrosivity of the water supply; and [3] growth of iron bacteria in the distribution system. The quality of water delivered to the consumer can be improved by considering only one of these items, but unless all three are considered, it is probable that the results will not be satisfactory, inasmuch as all three problems frequently go hand in hand.

The methods outlined in this discussion represent only a small number of the potential solutions and are, in general, limited to the author's experience in the field. Each red water problem requires a solution custom-tailored to fit the particular water in question. The solutions outlined will completely correct problems in the main distribution system and will improve conditions on dead ends enough to minimize complaints and frequently eliminate them. For a uniformly successful solution, the author recommends the provision of circulation for dead ends in addition to the procedures outlined.

Application of Safety Program to Water Works Industry

By Raymond J. Faust

A paper presented on Nov. 6, 1952, at the Virginia Section Meeting, Old Point Comfort, Va., by Raymond J. Faust, Exec. Asst. Secy., American Water Works Assn., New York.

IT is commonly assumed that the water industry is a relatively safe field in which to work. It is almost obvious that the gas and electric utilities, and perhaps the communication utilities as well, are potentially more hazardous for employees than are water utilities. Also, it is expected that the accident frequency and severity rates for these three utilities would clearly demonstrate this relationship.

No doubt this relative safety was true some years ago, but not today. The gas, electric, and communication utilities recognized the detrimental effects of accidents on production and on the morale of personnel, and decided to do something about it. They instituted safety programs which brought immediate and startling results. They proved that safety was a sound business activity. The National Safety Council supplied the data on accident rates, both for frequency and severity, which are given in Table 1. One glance at the rates will convince the most skeptical person that safety is good business.

To make the data in Table 1 intelligible, frequency and severity rates must be defined. Frequency is expressed as the number of disabling injuries sustained for each 1,000,000 man-hours of work. A disabling accident is defined as one in which the injured worker is unable to return to work on the day following the accident. Thus, if he reports to work at any time on the day following the accident, no lost-time accident is recorded. In contrast, the severity rate is based on days lost for each 1,000 man-hours of work.

According to the National Safety Council frequency and severity rate for utilities, the water utilities are a relatively hazardous industry in which to work—for example, a comparison between the accident frequency rates of the communication and water utilities for 1950 shows that accidents occur in the water industry at a rate 12.4 times faster than in the communications field. The water utilities frequency rate is 2.12 times the electric utility rate and 1.58 times the gas utility rate. Inasmuch as water utilities would seem to be potentially less hazardous than the gas and electric utilities, though perhaps more hazardous than the communications industry, it is evident that the water industry has not been active in a protection program for its employees.

In addition it should be pointed out that the few—38 out of a total of more than 16,000—water utilities reporting their accident frequency and severity rates to the National Safety Council

serve some of the larger towns; no relatively small towns are included in the group. As it is common knowledge that the highest accident rates occur in small shops and utilities, it is apparent that the accident rates for the water industry reported by the National Safety Council are somewhat lower than they would be if a reasonable cross section of the industry were used in the compilation of the rates.

Table 2, which shows the accident rates of the electric companies in the country for 1951 (*1*) substantiates the point that company size and accident rates have an inverse relationship.

TABLE 1

Frequency and Severity Rates for Utilities and Industries

Utility	Number of Utilities Reporting in 1949	Accident Frequency Rate			Accident Severity Rate		
		1949	1950	1951	1949	1950	1951
Communications	59	2.14	2.05	1.79	0.15	0.12	0.09
Electrical	238	14.02	11.96	11.06	2.37	1.96	2.00
Gas	425	17.92	16.03		0.99	0.79	
Water	33	33.00	25.50	30.00	0.90	1.05	0.72
All industries (avg. of 40 types)				9.06			0.97

A Safety Program

From the foregoing evidence, it seems obvious that the water works industry in the U.S. has a poor accident record compared with the other utilities. This is due primarily to the fact that the industry, as a whole, has no safety program. If the need for a safety program is recognized, the next question is, what can be done about it and, especially, what can be done to help the small water utilities inaugurate such a program?

Fortunately, the answer to that question is not as difficult today as it was a year ago. The author is certain it will be still less difficult to answer a year from now. This optimism is based on progress made during the past year and the increased impetus which the program is gathering from day to day. Water works executives are beginning to show an active interest in safety and are arriving at answers to some of the problems.

A safety program must first be sold to the water works executives and they, in turn, must sell it to their staffs. All employees, from top to bottom, must actively participate in the program to make it a success. Safety then becomes a personal responsibility of every employee. If this premise is accepted, the next logical step in the establishment of a safety program is education.

Education

To educate the employees to think, act, and live safety, many avenues of approach are available. It should be recognized, however, that to obtain maximum results, the educational programs must be kept on a local basis. Weekly or monthly discussions and review of local accidents with the employees should be a significant part of

any safety program. In addition, one or all of the following methods in safety practice education may be used:

1. Appoint a safety practice committee in the AWWA section and keep it active.

2. Include a paper or panel discussion on safety practices annually on the section program. Present material of local origin in preference to outside material.

3. Insist that established short courses for water plant personnel include safety practice material and make the subject a major, rather than a minor, item of study.

TABLE 2

Accident Rates of Electric Companies for 1951

No. of Employees	No. of Companies	Frequency Rate	Severity Rate
More than 5,000	13	10.86	1.16
2,000–5,000	27	8.47	2.18
1,000–2,000	42	11.72	2.54
500–1,000	30	15.15	2.56
100– 500	55	18.50	3.62
Less than 100	55	21.53	4.51
Total or avg.	222	11.06	2.00

4. Use National Safety Council or similar material wherever possible to promote safety consciousness.

5. Stress the need for accident reporting, analysis of every accident, and the ascertaining of annual frequency and severity rates.

6. Insist that every employee take a Red Cross first aid and safety course. That it pays big dividends is illustrated by the analysis (Table 3) of a study of 64 water utilities operated by the American Water Works Co. The decrease in the number of lost-time accidents per 1,000,000 man-hours worked from 24.59 to 8.20 and the decrease in the number of days lost per 1,000 hours from 1.407 to 0.060 indicate a rather remarkable improvement as the percentage of people having first aid training increases.

Safety Appraisal

A successful safety program must also provide more than educational opportunities for the employees. It needs a plan of implementation. A successful plan of implementation must recognize the fact that more than 80 per cent of the 16,000 water utilities in the country are small and employ sometimes one or only a few people. These small utilities cannot afford to employ a safety director to guide their program and need some other approach to enjoy the advantages of a safety program. A simple solution would be the development of a short—one sheet—self-appraisal safety form for use on an annual basis by each small utility. The appraisal forms could be filled in by all utilities wishing to participate in the program. To obtain the greatest benefit from the safety forms, they should be reviewed for accuracy in establishing local accident rates by competent local people—perhaps by the office of the state sanitary engineer or by the AWWA section's committee on safety practice. To popularize the activity and to assure it public atten-

TABLE 3

Effect of First Aid Training on Accident Rates

Personnel Having First Aid Training—*per cent*	Frequency Rate	Severity Rate
0	25.88	1.407
1–10	24.59	0.286
11–50	22.83	0.106
51–100	8.20	0.060

tion, a section award should be established and presented to the utility receiving the highest safety rating for the year, or perhaps for the greatest improvement in safety rating for the year, or both.

A safety practice program offers a great opportunity to the AWWA sections, as well as to the state sanitary engineer's office, for major accomplishment in both the water works profession and in public health. Here is an important program which can succeed if given a chance, and one in which both the employees and the utility can share equally.

AWWA Action

The American Water Works Assn. is very much interested in safety practices. Wendell R. LaDue, chairman of the Committee on Water Works Administration, in 1950 recommended to the Board of Directors that a task group be appointed to study the present status of safety programs in the industry. The task group report, which was presented at the Miami Convention in 1951 and published in the JOURNAL in June 1951 (*2*), pointed out the general lack of a safety program in the water industry and suggested the need for additional study. The Board followed this suggestion in January 1952 when it authorized the formation of four new task groups to study and report on safety practices in the following functions: supply; treatment and pumping; distribution; and administration. It is expected that these groups will submit their reports at the 1953 convention. It is hoped that these reports will form the nucleus of a safety practice manual or perhaps a chapter in the Board's authorized superintendents' manual. Thus, the Association is aiming at a comprehensive safety practice program for all. To obtain the benefits of such a program, however, the utilities must apply it to their activities. The final decision to "play safe" rests entirely with the water works man.

References

1. *Edison Electric Institute Bull.* (Aug. 1952).
2. TASK GROUP REPORT. Safety Practices. *Jour. AWWA*, **43**:423 (June 1951).

A Safety Program for the Water Utility

By James B. Ramsey ann H. Louis Roose

A paper presented on Sept. 22, 1952, at the Missouri Section Meeting, Jefferson City, Mo., by James B. Ramsey, Chief Engr. and Supt., and H. Louis Roose, Safety Engr., both of the Kansas City Water Dept., Kansas City, Mo.

IN August 1951 the Kansas City Water Dept. took the first step toward establishing a safety program. As a result of this program, the accident frequency rate for the first eight months of 1952 was less than one-fourth the rate for 1951.

A safety program is really good business. It pays off in big dividends. A check of the records recently showed that the cost of carelessness to the Kansas City Water Dept. for the period March–September 1952 was $4,360, compared to $16,473 for the same period in 1951. These costs included wages paid to injured employees while they were not working because of their injuries, doctor and hospital bills, and settlement of claims for injuries and damage to property. In six months, $12,113 was saved on these items, all of which are directly affected by a safety program. In addition, employee morale and efficiency have increased tremendously. There is no adequate yardstick for measuring the monetary value of these assets, but it undoubtedly amounts to thousands of dollars a year.

The Kansas City Water Dept. safety program has been introduced as a cold-cash proposition, but there are other considerations. Some laws require that the employer provide a safe place for his employees to work. The penalty for failing to do so is sometimes rather severe. The moral aspects must also be considered. No one likes to have people hurt or killed if it can be avoided. It is decent and humane to prevent the death or injury of the man on the job. All too often in the water works business and in other businesses a profit must be shown to be available before a new project can be undertaken. For that reason, the author has stressed the financial benefits of an active, functioning safety program.

Weiser (*1*) recently stated, and the authors agree, that: "A safety program bears some of the aspects of a good contract; it confers benefits on both parties. It benefits the business and it benefits the people who work for the business. We should be thankful indeed that accident prevention, although justified by good business management, does confer important benefits upon all concerned."

The Kansas City Water Dept. has just started a safety program and is already counting the benefits in the thousands of dollars. The department expects to do much better, as it is aiming at nothing less than a perfect accident record. Such a record would certainly benefit the company financially and would benefit and encourage all of the employees.

Accident Rates

Statistics compiled by the National Safety Council and other reliable organizations show that an average of approximately 16,000 occupational fatalities and 2,000,000 disabling occupational injuries occur each year and that the annual cost of these on-the-job injuries is almost $2,670,000,000.

Many water works men feel that their plants are too small to have a safety program. Data compiled by the U.S. Dept. of Commerce and the National Safety Council show that plants employing fewer than 100 workers have an accident frequency rate almost double that of plants employing 1,000 or more. It should be remembered that 90 per cent of all manufacturing plants employ fewer than 100 workers. The percentage of water works plants with fewer than 100 employees is even higher.

The 1951 national all-industry accident frequency rate was 9.06. This figure means that there were 9.06 disabling injuries or lost-time accidents for every 1,000,000 man-hours worked. A lost-time accident is defined as one in which the injured worker is unable to return to work on the day following the accident.*

In 1951, the average of the 36 water works companies reporting was 30.0—more than three times the all-industry average. In the seventeen reporting water works plants which had fewer than 100 workers, the figure was 57.9—about twice the average of the large water plants and more than six times the all-industry average. Although these figures for the water works industry came from only 36 plants, they probably paint too favorable a picture of the industry because they were from plants that have some kind of safety program, as indicated by their reporting accident records to the National Safety Council.

The figures show that the water work industry is not a safe one to work in. They also show that the small water plant is at least six times as dangerous as the average of all other industries by which a worker might be employed. The American Water Works Assn. established a safety committee several years ago, and, in 1952, the Missouri Section appointed such a committee, of which the senior author is chairman, to deal with this problem.

Establishing a Safety Program

Making the decision to start an activity is often harder than carrying it out. For years the Kansas City Water Dept. had been in favor of a safety program, but had never made the decision actually to have one. Naturally, nothing at all was accomplished. But when it was decided to have a safety program—the already bad accident record seemed to be getting worse—things really started to happen. A man was hired to take charge of the program. Many plants are not large enough to be able to afford a full-time safety man, but, in a small plant, a full-time safety man is not required. The heads of these small utilities seem to forget that often in the past they have taken on new or additional responsibilities when work assignments had to be redistributed or old and unnecessary procedures discarded to make way for the new work. Starting a safety program is the same kind of problem. By making someone in the organization re-

* Assuming a 40-hour week and two weeks' annual vacation, a laborer would work 2,000 man-hours per year.

sponsible for running a safety and accident prevention program and by arranging his work load so that he can handle the new assignment, a safety program can be established.

The Kansas City Water Dept. has had to adjust to the safety program. The authors have had to rearrange schedules to accommodate safety work. The superintendents, foremen, and even the workers have felt the impact of this new responsibility and have found ways to absorb it so that it is becoming a part of the normal work activities.

No matter what size the plant, someone must lead and be responsible for the safety program, just as there are leaders for other activities in the plant. As the program advances, the work load on the leader will not be as great as it appeared at first. When the idea begins to catch on, the responsibilities for the program will become distributed among all the employees.

Safety Consciousness

The Kansas City Water Dept. felt that the real key to the success of a safety program was the development of an attitude of safety consciousness in the mind of each employee. This feeling has been intensified after a year's experience, and most of the department's activities have been aimed at increasing safety consciousness.

Safety is primarily the product of engineering and training. Safety engineering, insofar as most plants are concerned, is primarily the maintenance and proper operation of machines, tools and equipment, and structures. Safety has already been engineered into most of these things by the manufacturers and builders. The user's part of the engineering is to maintain them in a safe condition and to operate them in a safe way.

Engineering can go only so far. In a water works safety program, engineering is secondary to training. Even if the best engineered equipment possible is used, the safety record will be scandalous if the workmen do not have the highly developed "safety consciousness" which can only be achieved through good training. In the authors' plant in 1951, before the safety program was initiated, only five out of 74 disabling accidents were due to defective tools, materials, or equipment. The remainder were due to unsafe acts or unsafe conditions.

Many things have been done in the Kansas City Water Dept. to develop an attitude of safety consciousness among all the people from top management down through the ranks to the lowest job of all. The first act was to pick out some feature of the operations which could be praised for a good safety record, and to demonstrate to all of the employees that management was definitely concerned with safety, or the lack of it; that management wanted to do something about it; that management's attitude was friendly and cooperative, not vindictive; and that the individual employee and his cooperative effort were the most important and necessary items for the success of a safety program.

A dinner for all employees who had an accident-free driving record for one or more years was held. Each employee was rated by the amount he drove while on duty—for example, anyone who drove only one-fifth of the time had to have a total elapsed time of five years without an accident to be eligible to attend the dinner. The company that carries the liability insurance

TABLE 1—*Kansas City Water Dept.*

Division	Employees	Hours Worked		No. of Minor Injuries Reported		
		1951	1952	1951	1952	May 1952
Administration	20	15,901	16,720	0	0	0
Collection	77	60,517.5	66,969	1	0	0
Engineering	20	13,659.5	16,671	0	0	0
Garage	7	5,480.5	5,994	0	1	0
North Kansas City	95	74,348	79,093	3	5	2
Pipeline	99	75,904	80,974	5	6	4
Turkey Creek	71	51,664	61,339	1	1	0
Water Service	71	67,340.5	58,405	5	6	1
Total	460	364,815	386,171	15	19	7

* Number of disabling injuries for every 1,000,000 man-hours worked.
† Average.

on the water department's vehicles cooperated by furnishing, free of charge, "safe driver's award" cards, which were signed by the city manager, and sterling-silver lapel pins on which were engraved the driver's name and number of years of accident-free driving. The city manager came to the dinner as the principal speaker and to present the awards individually to each driver. Other guests included a representative of the National Safety Council, the head of the police traffic bureau, and a representative of the water department's insurance company.

The dinner was a huge success. Management gained a tremendous amount of good will, and employees were recognized and honored for good safety records. And best of all, everyone in the water department was aware that something new had been added. Safety consciousness had gotten its foot in the door. Many water departments feel they could not have an event of this kind. A year ago the Kansas City Water Dept. would have felt the same way, but ways and means were found. Certainly a celebration of some type could be held in any water department.

Recognition

The Kansas City Water Dept. has maintained the policy of recognizing good safety records as they are established. Primarily this recognition has taken the form of letters of commendation from the director of the department to the individuals or sections concerned. Copies of these letters are posted on all bulletin boards so that all employees know that management has a continuing interest in safety.

One of the most spectacular incidents resulting in outstanding recognition occurred recently. One of the water department employees, Nora Brown, saved the life of a fellow workman by his cool-headed, quick action during an emergency and by the application of first aid afterwards. The plant safety supervisor wrote up the details of the incident, obtained affidavits from witnesses and the attending physicians, and submitted the in-

Accident Report, 1951 and 1952 Through May

No. of Major Injuries			Days Charged		Severity—*hr*			Frequency Rate*	
1951	1952	May 1952	1951	1952	1951	1952	May 1952	1951	1952
0	1	0	0	2	0	16	0	0	59.8
2	0	0	6	0	64	80	0	33.5	0
1	0	0	30	0	242	0	0	73.2	0
0	0	0	0	0	0	0	0	0	0
4	1	0	8.5	3	74	33	2	53.8	12.6
13	5	1	128	39	1,586	759	201	171.3	61.7
5	0	0	32.5	0	262	11	8	96.8	0
3	0	0	12	0	104	24	11	44.5	0
28	7	1	217	44	2,332	923	222	76.8†	18.3†

formation to the Red Cross for consideration for an award. The Red Cross awarded Nora Brown a certificate of merit, its highest award for lifesaving and first aid. The presentation was filmed for television. This was an unusual occurrence, one that will not happen in many plants, but the point of the story is the importance of giving recognition to outstanding safety work, another strong plank in the safety consciousness platform.

First Aid

One of the next steps in the Kansas City program was the training of employees in first aid. Such training ranks high as an aid in establishing safety consciousness. The Red Cross first aid textbook lists four purposes of this training, the first of which is: *"To prevent accidents.* Experience shows that people trained in first aid are safety conscious and their accident rate is lower than that of untrained persons." The Kansas City Water Dept. has given the first aid course to 58 employees to date. The department intends to continue to conduct several classes a year. The course is given on company time and the water department buys the textbooks and materials. This course is available through the Red Cross throughout the country.

Safety Meetings

Safety meetings at all levels in the Kansas City Water Dept. have been started. The first meetings were those among the top supervisors. Meetings were held weekly at first but are now scheduled once each month. These meetings last approximately two hours and are concerned with ways of carrying on the program, discussion of accidents that have happened, and means for preventing accidents.

After a few of these supervisors' meetings had been held and the supervisors were beginning to feel at ease in such a meeting, they started holding similar meetings among the employees in their divisions. These meetings are held on company time either at the

beginning of the work day or just after lunch time. They last approximately 30 min or less. Those attending any one meeting either work together as a crew or do similar work in separate crews. The meetings have settled into a regular pattern and are held either twice a month or once a month, as circumstances seem to require. The meetings are conducted by a chairman selected by the group and minutes of the proceedings are kept. These meetings have been extremely worth-while activities. The majority of the employees are very interested in cooperating with management in this program. The meetings give the employees a chance to tell of some unsafe condition or procedure and to get corrective action.

One of the first rules laid down by management was that every question, suggestion, complaint, or idea on safety or accident prevention raised by the employees had to be acted on one way or another by supervision. To be sure that action is taken, copies of the minutes of the meetings are filed with the superintendent and safety supervisor. Some suggestions are made because of ignorance of the circumstances or lack of understanding on the part of the employee. A careful explanation, demonstration, or illustration is made by a foreman, the superintendent, or the safety supervisor before the whole group, either at that meeting or a subsequent meeting, to clarify the matter both for the employee who raised the question and for the rest of the group. There have been no situations to date that have not been handled to everyone's apparent satisfaction. Literally dozens of good, sound suggestions that have really contributed immensely to the success of the program have been made.

One big advantage of these safety meetings is the freedom men feel to express their opinions with confidence that they will be given consideration. Many of the really good suggestions that have come out of these safety meetings had been made before the safety program was initiated, but the foreman or superintendent had not considered the matter important, or had neglected to act, or, frequently, had simply passed the buck to someone else. Frequently the men were reluctant to push their suggestions because they naturally feared displeasing their superiors. In group meetings and in the atmosphere that the department has tried to establish, the men need not fear to express their ideas. Also, the opinion of the group on certain specific incidents of unsafe work habits and practices of individual employees has carried enough weight to cause some individuals to change their ways for the better. The kind of attitude and resulting lack of action that existed before the safety program was initiated contributed greatly to poor morale, careless and inefficient work, and a shamefully high accident rate.

Since the safety program has been in progress, morale is much better than it has been in years. Equipment has never been in better shape. The employees feel more important in their jobs because they know from many examples in the last year that management is really interested and wants to get the worker's opinions and suggestions on working conditions. They have a feeling of belonging and being a part of the team that they never had before.

Safety Records

One very important item in a safety program is the maintenance of an ac-

cident record. Records in safety work permit current operations to be compared with past operations and provide a means of planning for the future. Records also help to establish a competitive spirit between divisions of a particular plant and between plants in the industry.

The Kansas City Water Dept. had kept accident records for a number of years as a part of the payroll record system. These records meant nothing, however, until they were compared with records of 67 other plants in Kansas City. The department was somewhat alarmed to discover that its record was twice as bad as the next worst utility, and that out of the entire list of 67 plants, only one other plant had a record as bad as that of the water department. The revelation that the water plant had next to the poorest safety record in Kansas City stung the department into action. The water department's position has been greatly improved and it hopes soon to have one of the safest plants in Kansas City.

TABLE 2

Accident Statistics of Kansas City Water Dept. for Year Ending Dec. 31, 1951

Man-hours worked	898,720
Avg. number of employees, operating divisions	359
Avg. number of employees, total	457
Number of lost-time accidents	74
Work days lost, actual	671
Work hours lost	5,368
Frequency rate	82.45
Severity rate	0.747

The furnishing of accident experience records of the various divisions of the company to every division has had a desirable effect. Those divisions having the worst records were embarrassed and are striving to do better and those having the best records are trying to maintain their favorable position. The division that had the worst record is still in last place, but the accident frequency rate for the first nine months of 1952 was only 44 per cent of the rate for a similar period in 1951. At one of the safety meetings in this division early in 1952, a foreman opened the meeting with the following statement: "Men, I have here a copy of our accident record for last year. It shows that if we are as careless and unsafe in our work as we were last year, there will be eight of us severely injured this month." That statement, made from the safety record of the year before, transformed the word safety into a very personal thing. Who was going to get one of those severe injuries?

The two divisions with the next worst records did not have a single lost-time accident in the first nine months of 1952. Until the record was made available to them, they did not realize how bad conditions where they worked were, and that those conditions were due, for the most part, to their own carelessness. These two divisions have a total of 144 men. Last year sixteen of these men suffered major injuries. The record showed that more than one out of ten would suffer a severe injury if they did not change their ways. One chance in ten makes poor odds when the penalty is severe injury or death—poor enough to make safety a personal matter.

Accident records are distributed each month to all supervisory employees. As shown in Table 1, these reports give the accident experience of each division for the last year and the current year to date, and for the latest month. The bottom half of the page contains a newsletter type of message on safety, such as the following:

TABLE 3

Nature-of-Injuries Summary

Type Injury	No. of Accidents	Per Cent of Total	Time Charge—*hr*	Severity *per cent*
Bruises, contusions, cuts, and lacerations	32	43.2	2,188	40.76
Sprains, strains	21	28.4	928	17.29
Fractures	8	10.8	1,528	28.46
Burns	5	6.8	176	3.28
Eye injuries	4	5.4	108	2.00
Miscellaneous (2 dog bites, 1 hernia, 1 heatstroke)	4	5.4	440	8.38
Total	74	100	5,368	100

Type Accident	No. of Accidents	Per Cent of Total	Time Charge—*hr*	Severity *per cent*
Falls on same level	7	9.46	576	10.73
Falls to another level	6	8.11	184	3.43
Slips causing strains (not falls)	10	13.51	928	17.29
Falling, sliding, flying objects	10	13.51	620	11.55
Caught in or between objects	17	22.97	1,824	33.98
Struck against object	14	18.92	992	18.48
Burns and scalds	5	6.76	176	3.28
Poisoning, infections (flood)	2	2.70	28	0.52
Other	3	4.05	40	0.75
Total	74	100	5,368	100

Hazard Patterns	No. of Accidents	Time Charge—*hr*	Severity *per cent*
Eye injuries	4	120	3.72
Defective tools, material, or equipment	5	136	4.22
Excavations, cave-ins, or climbing in, out, or over	7	652	20.22
Operation of cranes, backhoes, and hoist equipment	6	700	21.71
Operation of tampers and jackhammers	6	784	24.32
Trucks or vehicles, injured by or in collision with	7	832	25.81
Total	35	3,224	100

We're headin' in the right direction as seen in the figures on this May report. A leg fracture prevented continuation of April's accident-free month. Several of the foremen whose men experienced minor injuries this month have reported that the same kind of accident will never happen again because the accident was investigated, discussed, the cause found, and preventive procedure agreed to by all the crewmen. That's teamwork!

Ever see a cat push her tail into a corner and stand off a dog? She does it only when she can't climb a tree or make a run for it. The foreman who alibis with "I told the guy!" is in the same kind of tight spot. One of his men disobeyed instructions and got hurt, and

he's making loud noises about what's wrong with human nature—the other fellow's. Suppose you do tell the guy. Suppose he gets hurt anyway, and you are called upon to explain. If all you did was to tell him, you might have saved your breath.

When you want a man to do a job your way—the safe way—you don't just tell him. You show him, explain, sell and convince him, and let him try it. You make him do it, yes, but stick with him, watch him do it, and check later on to see that he does it that way and gets along all right. There's more to training than just conversation! The foreman who knows this will most certainly be able at year's end to point to the work record of his crew and show top rating for safety, quality, and quantity performance—and he'll never have to back his tail into a corner and desperately try to stave off savage accident or injury facts with "I told the guy!"

An annual record (Table 2), as well as an annual summary of the types of injuries, types of accidents, and hazard patterns (Table 3), is also prepared. Occasionally, a one-page instruction sheet on "Beating the Heat," "Safety in Teamwork," or other similar subjects is distributed.

Another innovation that has improved safety consciousness is the safety scoreboard. A bulletin board placed in a prominent spot in the plant or division headquarters shows the number of days that have elapsed since the last minor or major injury.

Accident Investigation

The importance of accident investigation cannot be overstressed. The Kansas City Water Dept. requires a report on every injury, whether minor or major. Every major injury is investigated fully to determine the circumstances causing the injury—whether it was due to an unsafe condition or an unsafe act—what action could have been taken to prevent the accident, and what action can be taken to prevent similar accidents in the future. Every accident is discussed with the work group involved as soon after the accident as possible. Most of these discussions are held at on-the-job meetings and usually the preventive remedies are suggested by the workers. It is desirable to have the victim at the meeting if it is at all possible to get him there. He is generally better able to tell what happened than anyone else and his presence makes the meeting more vital and significant in the eyes of the rest of the workers.

National Safety Council

The Kansas City Water Dept. joined the National Safety Council shortly after starting its safety program and has received many worth-while benefits from it. In addition to the consultation services, publications, and statistical services that have been of great help to the safety supervisor, innumerable pamphlets, posters, and bulletins have been available for distribution to all the employees, or for posting on bulletin boards. Some of this material—such as small cartoon type posters that are inserted with each employee's paycheck and that are changed for each payday—has been ordered at extra cost. Most of the material used, however, has been available as part of the service furnished from the membership dues. All of this material has been directly related to the water department's safety program because it has all helped to develop safety consciousness.

Conclusion

All of the efforts of the authors' water department have been aimed at developing safety consciousness. The statement that safety consciousness is all there is to a safety program is correct to a certain extent, as it is impossible to have an effective safety program if employees are not conscious of safety. A safety program contains many other elements—such as safety meetings, first aid courses, safety records, accident investigations, safe job procedures, safety rules and regulations, awards and penalties for good or bad safety performance, and safety committees—but they are all meaningless in the absence of safety consciousness. The Kansas City Water Dept. has changed many job procedures to make them safer and has established many rules. Few if any of the workers, however, have been acutely aware that such changes were being made because the changes have come naturally with the new attitude.

The safety program carried out in Kansas City could be duplicated in any other water plant, regardless of size, with only slight alterations to fit special requirements. The benefits of an active safety program are many and are well worth the effort.

Reference

1. Weiser, C. H. Safety in Small Business. *Trans. Natl. Safety Congr. 39th Congr. 1950* (1950).

Liberalization of NPA Regulations

Effective Jan. 1, 1953, the liberalization of CMP Regulation 6 by the National Production Authority permits water and sewage systems to self-authorize purchase orders for the following amounts of controlled materials per project, per quarter for construction:

25 tons of carbon steel and alloy steel, including all types of structural shapes (not to include more than $2\frac{1}{2}$ tons of alloy steel and no stainless steel)

5,000 lb of copper and copper-base alloys

2,000 lb of aluminum (raised to 4,000 lb, effective May 1, 1953)

The former limitations on self-authorized purchases were: 5 tons of carbon steel, 1,000 lb of copper, and 2,000 lb of aluminum.

Water and sewage systems making self-authorized purchases will use the allotment symbol T–9.

Also effective Jan. 1, 1953, the dollar limit on DO rating authority for purchase of noncontrolled building equipment and production machinery is raised to $100,000 on building equipment and $200,000 on production machinery.

The new provisions will simplify the paper work required to obtain controlled materials needed for small construction projects. Materials in excess of the limits stated can be obtained only through facilities of the NPA Water Resources Division.

Aerobic and Anaerobic Iron Corrosion in Water Mains

By C. A. H. Von Wolzogen Kühr and L. S. Van der Vlugt

A paper originally published in the Nov. 22, 1951, issue of Water, *a publication of Moorman's Periodical Press, The Hague, Netherlands. Translated from the Dutch by Willem Rudolfs, Chairman, Dept. of Sanitation, Rutgers University, New Brunswick, N.J.*

THE points to be covered by this paper may be summarized as follows:

1. Mechanical stresses that develop in different parts of the iron during the production of water pipe provide the seat for cathodes and anodes on the iron surface. Clean, as well as poorly protected, iron surfaces are predestined to corrode in the anodic areas.

2. The primary internal corrosion reaction:

$$Fe + 2H_2O \leftrightarrows Fe(OH)_2 + 2H$$

moves to the right if the corrosion hydrogen and ferrous hydroxide are removed from the chemical equilibrium. During aerobic corrosion, this removal occurs by chemical oxidation, resulting from the dissolved oxygen present in the water and forming water and ferric hydroxide.

3. The chemical reaction is soon displaced by a biochemical oxidation caused by two specific physiological groups of bacteria—oxyhydrogen bacteria and iron bacteria. This oxidation process, which is catalytically accelerated, can be viewed as the result of a microbiological accumulation of these bacteria. The oxidation of the corrosion hydrogen into water is accomplished by the oxyhydrogen bacteria on the cathodic iron surface, and the oxidation of ferrous to ferric hydroxide by the iron bacteria on the anodic area.

4. The localized accumulation of a voluminous corrosion product in the form of iron rust, bound by iron bacteria and strengthened by incrustations of calcium carbonate, manganese dioxide, and other compounds into a resistant mass, induces the formation of tubercles. The tubercles are a visual manifestation of the anodic action on the internal iron surface. The soluble ferrous compounds diffuse outward to the surface of the tubercle where they are oxidized by iron bacteria. The insoluble hydroxide deposits in layers, and an increase in the size of the tubercles results.

5. Gradually more and more of the iron surface is covered by the continuous deposition of iron rust which brings into action the differential aeration principle of Evans (*1*; *2*, p. 100) whereby the anodic areas continue to expand. The tubercles may expand individually or combine into groups.

6. If the oxygen consumption of the iron bacteria is high, the inside of the tubercles may become gradually anaerobic. In accordance with the Pasteur principle (*3*), this anaerobic condition is a prerequisite for the develop-

ment of anaerobic sulfate-reducing spirilla which are present in the tap water. The aerobic iron corrosion begun initially by the oxyhydrogen and iron bacteria is changed inside the tubercle to anaerobic corrosion by the sulfate-reducing spirilla.

7. When the progress of corrosion is governed primarily by the depolarization process, the attack on iron can be reduced simply to the action of hydrogen-oxidizing bacteria, no matter whether the oxidation is caused by aerobic oxyhydrogen bacteria or anaerobic sulfate-reducing spirilla.

8. A study of the principles involved in internal iron corrosion of water mains leads to a consideration of the economic necessity for inactivating the cathodic and anodic differences—caused by tension in the metals produced during construction of the pipes—by application of proper internal protective materials.

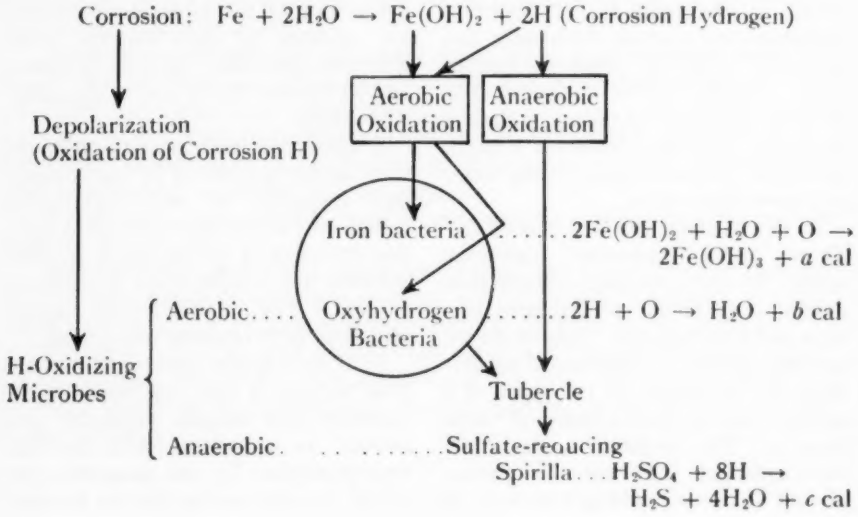
9. The following is a schematic representation of the iron corrosion process:

Iron Corrosion Research

Rust is a common occurrence in water distribution systems. Water flushed from dead ends is turbid because of the yellow-brown or brown iron rust, which consists primarily of the corrosion product ferric hydroxide; hence, the iron exists in a trivalent condition.

The iron rust in the mains should not be confused with the ferric compounds existing in the water itself. Microscopic examination of iron-bearing water frequently shows the presence of threadlike iron bacteria, whereas examination of the inside wall of the pipe may show that the protective bituminous coating is in poor condition. Thus, contact between water and metal is possible, and corrosion has taken place.

A bituminous coating does not give protection when cracks and crevices reach the metal surface. Moreover, one part iron may cause more than ten times that amount of wet iron rust (*4*). Because of the increase in vol-



ume, the localized cracks are widened (*5*).

On improperly or poorly protected pipe, tubercles are usually present in the form of humps, knobs, clods, pimples, pocks, or warts, which differ in appearance and size. These excrescences may occur in groups similar to mountains and hills in miniature. The color varies from light yellow to dark brown. Internally the structural layers are often clearly discernible by the difference in color. Eventually the enlarged tubercles may materially reduce the diameter of the pipe and obstruct water flow.

Old tubercles are frequently hard because of incrustations of calcium carbonate, manganese dioxide, and compounds of magnesium, silicic acid, and phosphoric acid (*6*). Opening of tubercles may expose a watery mass containing ferrous sulfide and hydrogen sulfide, undoubtedly the result of sulfate reduction, while the surface of the pipe at the location of the tubercle is attacked. The tubercles vary in appearance and composition, depending upon the character of the water. Olsen and Szybalski (*7*), in reviewing the literature, indicate that tubercles are frequently related to corrosion pittings, whereas iron bacteria (*Gallionella ferruginea, Leptothrix ochracea* and others) are present in the tubercles. Olsen and Szybalski point out that the relation between the bacteria and tubercles should be considered with caution. From their experiments these writers conclude that iron bacteria play a decided role in the corrosion process, but the authors' investigations indicate that another microbe group with different physiological characteristics is most important. Other papers (*8–12*) dealing with the internal attack of iron water pipes state that iron bacteria play a role. The authors agree with Hadley (*13*) that the role played by iron bacteria in internal iron corrosion has not been clarified by the various investigations. He indicates the need to clarify the relation between iron bacteria, sulfate-reducing spirilla, and tubercle formation. To date no study on internal attack showing the connection between aerobic and anaerobic iron corrosion and the aerobic and anaerobic flora present is known. This paper deals with the relation between internal corrosion and the aerobic and anaerobic organisms present in the water.

Aerobic Iron Corrosion

From a physical-chemical viewpoint, the corrosion reaction,

$$Fe + 2H_2O \leftrightarrows Fe(OH)_2 + 2H$$

is a heterogenic equilibrium, and the "principle of labile equilibrium" of Van't Hoff and Le Chatelier is applicable, which means that the reaction will proceed to the right or in the direction of corrosion if both reaction products are removed from the equilibrium. This removal occurs through oxidation when the ferrous hydroxide [$Fe(OH)_2$] is changed to the insoluble ferric hydroxide [$Fe(OH)_3$] and the hydrogen to water. The removal of the hydrogen is called depolarization.

Winogradsky (*14*) showed in 1888 that the energy released by the exothermic reaction of the oxidation of ferrous to ferric iron is utilized by iron bacteria for metabolic processes and that the reaction is thereby catalytically accelerated. Cholodny (*15*) states that a ferrous salt solution is only slowly oxidized by oxygen from the air if no catalytic substance is present. Natural waters containing ferrous salts are comparatively rapidly and completely

oxidized to the ferric hydroxide, however, even when there is restricted access to air. The conviction of Cholodny that the increased rate of oxidation is biochemical in nature—that is, connected with microorganisms—is based upon the fact that oxidation of ferrous to ferric iron proceeds very slowly when the activity of living microbes is excluded by a disinfectant or by sterilization.

That oxidation of ferrous salts in water solution can take place by exposure to the atmosphere, even under low oxygen tension in the presence of iron bacteria, has also led to the conclusion that the microbes hasten the oxidation reaction catalytically. Winogradsky (*14*) concluded that the oxidation process was to be the energy source for the chemoautotrophic metabolic processes of the iron bacteria. Many attempts have been made to discredit this hypothesis, but the development of microbiology has substantiated the general conclusions (*16*).

The massive growth of autotrophic iron bacteria in water distribution systems is a result of internal iron corrosion and is independent of the aftergrowth of various types of water bacteria that develop through assimilation of soluble organic substances in the water. The aerobic iron corrosion process in tap water is catalytically accelerated by specific microorganisms, the iron bacteria just mentioned, and the microbes oxidizing free hydrogen.

Free Hydrogen-oxidizing Microbes

If water in iron transmission or distribution mains is examined for microbes connected with the iron corrosion process, it is necessary to consider microorganisms capable of hydrogen oxidation as well as the ferrous-oxidizing bacteria. In general, the cathodic hydrogen developed by corrosion in normal water as the electrolyte is the starting point of each corrosion process (*17*); hence, the corrosion reaction is:

$$M + 2H_2O \rightarrow M\ (OH)_2 + 2H$$

where M is a divalent metal and H is the corrosion hydrogen. When oxygen acts as hydrogen acceptor, the depolarization reaction is:

$$2H + O \rightarrow H_2O + 6.9 \text{ kg cal}$$

This exothermic reaction sets free a quantity of energy.

Many organisms are capable of utilizing free hydrogen; these microbes are called hydrogen oxidizers. Kluyver and Manten (*18*) discuss the metabolism of bacteria that oxidize molecular hydrogen. De Saussure observed in 1839 that mixtures of hydrogen and oxygen disappeared when they came into contact with soil. Presumably water was formed. In 1892 Immendorf showed that addition of chloroform to the soil prevented the utilization of the gas mixtures, indicating the biological nature of the process. Kaserer in 1905 and Niklewski in 1906 showed experimentally that bacteria were responsible for hydrogen oxidation. Although Niklewski described the organism, he was then unable to obtain it in pure culture, but he succeeded in 1910. The bacteria developed only in mineral media if the oxygen tension of the gas atmosphere was considerably reduced. Two types were isolated which also developed well in organic media, showing the facultative character of these autotrophic bacteria. When organic material was added to the mineral media, hydrogen oxidation was inhibited.

The hydrogen oxidizers belong to very different natural groups of bac-

teria, some of which have the power to oxidize free hydrogen. Grohmann showed in 1924 that the widespread hydrogen-oxidizing bacterial types differ greatly in morphological character. Kluyver and Manten (*18*) showed in 1942 that suspensions of "resting cells" of the autotrophically obtained, hydrogen-oxidizing organism, *Hydrogenomonas flava,* were able to oxidize simultaneously hydrogen and an organic substrate in such a manner that both respiration processes are superimposed. This observation leads to the conclusion that the hydrogen oxidizers contain a specific catalytic system for hydrogen activation along with the usual substrate hydrogenase.

As noted previously, the released energy in the hydrogen oxidation reaction is used by the organisms for their physiological functions, including the formation of organic material for growth and metabolism. Kluyver and Manten (*18*) point out that according to present physiological views, carbon dioxide and hydrogen are the starting points for the formation of organic material and not carbon dioxide and water used in the photoautotrophic synthesis of green plants. They call attention to the necessity for a simultaneous carbon dioxide reduction and hydrogen oxidation reaction. The exact coupling between both reactions of this chemoautotrophic process is unknown.

Inasmuch as hydrogen becomes available during corrosion of iron pipe, and the water contains oxygen, carbon dioxide, bicarbonates, and all other physiological elements necessary for life, and only small quantities of soluble organic material, the water is an excellent substrate for the development of autotrophic hydrogen-oxidizing bacteria. It was logical, therefore, from the viewpoint of aerobic iron corrosion, to study the activities of these organisms in tap water flowing through internally corroding pipes. Before these studies are discussed, however, a few remarks on the catalytic acceleration of the hydrogen oxidation reaction by the aerobic metal corrosion will be made. The reaction caused by the bacteria in a hydrogen-oxygen mixture is catalytically similar to the catalytic effect of finely divided platinum. Platinum, as platinum sponge or platinum black, absorbs hydrogen and oxygen. A mixture of corrosion hydrogen and atmospheric oxygen is also operated on by the hydrogen oxidizers in accordance with the hydrogen oxidation reaction, which, of necessity, means a catalytic acceleration of the reaction, connected chemoautotrophically with the life process of the microbes.

It is a fact that the corrosion hydrogen is oxidized by the atmospheric oxygen without the catalytic effect of the hydrogen-oxidizing bacteria, which means that this hydrogen does not exist as molecular hydrogen, because the latter is not oxidized by molecular oxygen. The corrosion hydrogen should therefore be considered to be in an active state—that is, atomic hydrogen. Thus, the greater reaction activity of oxidation by atmospheric oxygen as an ordinary chemical process is explained. Inasmuch as the corrosion hydrogen from the iron corrosion process exists in an atomic condition, the catalytic acceleration of the oxidation of this hydrogen by hydrogen-oxidizing bacteria must be caused by the activation of the oxygen; hence, the oxygen in this reaction also exists in an atomic state. This explanation is in accordance with the previously discussed catalytic oxidation of ferrous compounds. The frequently un-

usual quantities of iron sludge in pipelines, in which the action of hydrogen-oxidizing bacteria is readily shown, supports the viewpoint developed above.

The depolarization reaction in aerobic iron corrosion by hydrogen oxidizers:

$$2H + O \rightarrow H_2O$$

may be compared with the anaerobic iron corrosion by sulfate-reducing spirilla:

$$H_2SO_4 + 8H \rightarrow H_2S + 4H_2O$$

The sulfate oxygen can oxidize the available activated corrosion hydrogen only through action of the sulfate-reducing bacteria, so that this oxygen, which is certainly not in a molecular state, must be considered to be catalytically activated—that is, its atomic state operates the hydrogen oxidation.

This analogy makes it possible to consider the hydrogen oxidation by aerobic iron corrosion as a process whereby the oxygen is activated through the catalytic effect of oxyhydrogen bacteria, which gives an advantage over the ordinary molecular atmospheric oxygen in the oxidation of the corrosion hydrogen. In principle, therefore, there is no difference between the action of oxygen in biochemical aerobic and anaerobic iron corrosion, so that both depolarization reactions can be considered from one angle to provide a clearer and simpler explanation.

Aerobic Bacteria

To determine the presence and activity of the commonly occurring, free hydrogen-oxidizing bacteria, tap water is passed for several months through a flask equipped with inlet and outlet and containing iron, aluminum, or zinc in plate form. During this period tubercles of corrosion products are formed on the anodic areas of the metal surfaces. The tubercles are collected from the plates and placed in an absorption apparatus filled with a washed mixture of hydrogen and oxygen or hydrogen and air. The former mixture is preferable because it can be

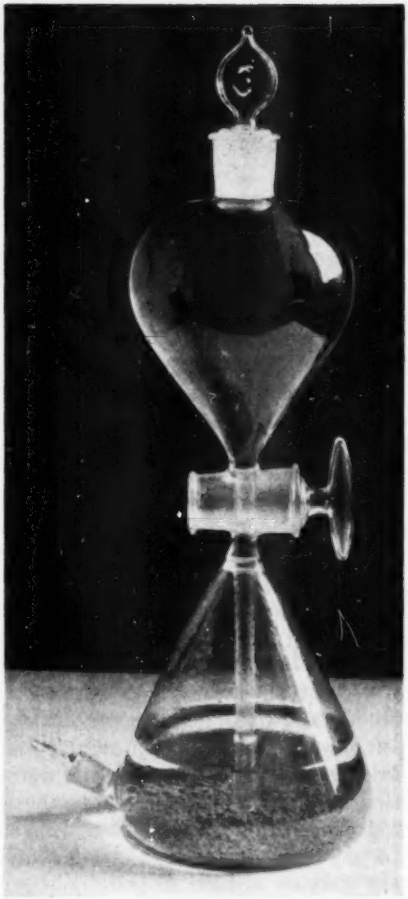


Fig. 1. Oxyhydrogen Absorption Apparatus

The apparatus consists of a separatory funnel fused on an Erlenmeyer flask.

completely utilized. In general, the gases begin to disappear after approximately two days, the rate of disappearance increasing with time until the active gases have been consumed. Occasionally the gas absorption starts after approximately 12 hours.

The lag in the reaction is probably due to the conversion of the oxidation of corrosion hydrogen, whereby the microbes accumulate in the tap water, to the hydrogen oxidation of the oxyhydrogen gas mixture. Because the hydrogen of the oxyhydrogen is in a molecular state, it probably oxidizes with greater difficulty than the already activated corrosion hydrogen. Time is required for rearrangement of the catalytic apparatus of the bacteria. When this rearrangement is accomplished, the oxyhydrogen reaction proceeds smoothly and regularly, although relatively slowly.

Inasmuch as the oxyhydrogen reaction in tap water leads essentially to the accumulation of the bacteria, it is clear that this water alone, because it contains the hydrogen-oxidizing bacteria, also produces the oxyhydrogen reaction. The metal corrosion product has an advantage of several days because of its larger concentration of hydrogen-oxidizing bacteria.

The absorption apparatus used consists essentially of a separatory funnel fused on an Erlenmeyer flask. There is a ground glass stopper at the intersection of the funnel and flask. Near the bottom of the Erlenmeyer flask, there is a glass-stoppered outlet. The end of the stem of the separatory funnel is submerged in the liquid (Fig. 1).

Using the iron in the rust obtained for test material, the oxyhydrogen reaction can be used to determine the activity of the bacteria present in the tap water. These bacteria, in contact with the corroding iron, oxidize the corrosion hydrogen to water with the aid of the dissolved oxygen in the tap water.

F. F. A. Cochius, the authors' associate, determined experimentally the activity of the oxyhydrogen bacteria in the metal corrosion product. A suspension of the corrosion product obtained from 50–300 mg metal, sufficient to fill entirely the lower section of the apparatus, was introduced into the apparatus through the tube. After closing, the washed oxyhydrogen gas was passed through the neck of the apparatus with the aid of a capillary so that the liquid was forced to the upper section of the apparatus and then the stopper in the middle of the apparatus was closed.

The absorption of the gas is observed by the reduction in liquid volume in the upper section when the stopper is opened. The reduction in volume during several weeks amounted to an average of 15 ml for iron, 3 ml for zinc, and 9 ml for aluminum per day. Maximum daily reductions were: iron 20, zinc 6, and aluminum 77 ml. The rate of gas consumption was probably related to the degree of bacterial infection of the corrosion product.

Microscopic observation showed that the iron corrosion product always contained iron bacteria, which utilize chemoautotrophically the energy-producing reactions:

$$\text{ferrous} + O \rightarrow \text{ferric}$$

The logical question is whether the iron bacteria are present alongside the oxyhydrogen bacteria or whether they themselves are oxyhydrogen bacteria which are able to perform the depolarization reaction:

$$2H + O \rightarrow H_2O$$

This question cannot, as yet, be answered. To identify chemoautotrophic iron bacteria that are present in the rusty sludge as oxyhydrogen bacteria, it is necessary to induce a pure culture of these iron bacteria to produce an oxyhydrogen reaction. To obtain such a pure iron bacteria culture is not yet possible. At any rate, it can be concluded that the stimulation of the aerobic iron corrosion process, through the activity of the oxyhydrogen bacteria, is strongly aided by the iron bacteria which oxidize ferrous to ferric iron, so that both groups of organisms are interrelated in this process. The oxyhydrogen test and the presence of iron bacteria in the iron pipe sludge are determinate factors in judging the occurrence of aerobic corrosion.

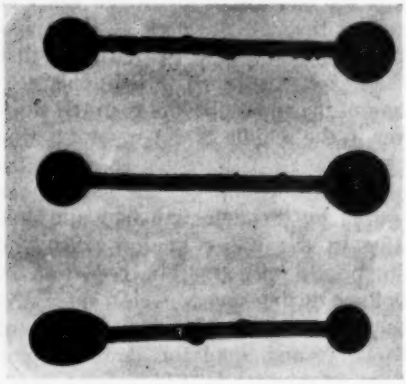


Fig. 2. Chemical Anodic Reaction

The medium consisted of 10 per cent gelatin and 0.25 per cent potassium ferricyanide. The reaction is shown at the end of three days.

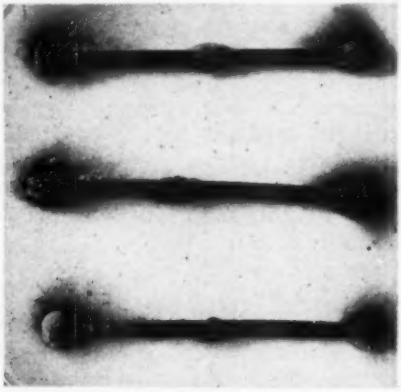


Fig. 3. Biochemical Anodic Reaction

The sample was allowed to remain in running tap water for 30 days.

The fact that in metal corrosion in tap water, whether corrosion of iron, zinc, or aluminum, activity of oxyhydrogen bacteria occurs, indicates that the function of these bacteria is the same—namely, oxidation of corrosion hydrogen to water. This means, from a corrosion standpoint, the depolarization of the cathode in the corrosion element is the most important condition for the initiation of corrosion.

Thus, it appears that the aerobic metal corrosion in tap water, especially attack on iron, is nothing but the result of an accumulation on the interior iron wall of corrosion hydrogen-oxidizing bacteria, namely the oxyhydrogen bacteria and the ferrous iron-oxidizing bacteria, both of which satisfy their chemoautotrophic requirements and thereby accelerate the catalytic iron corrosion process.

Water Main Corrosion

From a chemical and biochemical viewpoint, a comparison between the cathodic and anodic parts of a metal surface can be made. These areas develop as a result of flattening, stretching, rolling, hammering, drawing, bending, cutting, and wringing whereas, in

addition to the heterogenic structure (*2*, p. 202–211) of the metal, tensions develop because of uneven cooling during production of the metal. These tensions form the seat of electrochemical potential differences when the metals come in touch with electrolytes. Differences in potential indicate cathodic and anodic spots in the metal, which are present in cast and drawn iron pipe surfaces as well as in the metal itself.

If a piece of iron, which has been subjected to mechanical action (nail, wire, sheet iron), is placed in a clear 10 per cent gelatine solution with 0.25 per cent potassium ferrocyanide, diffusion spots of Turnbull blue develop in a few hours or days, with cathodic fields in between (*19, 20*). Cathodic and anodic fields can also be developed biochemically by subjecting the iron to flowing tap water. After a few weeks, iron rust accumulates wherever the iron is apparently anodic, whereas the cathodic spots occurring in between the anodic areas are not affected. Experiments with the rust show it to produce the oxyhydrogen reaction and to contain iron bacteria. These results show that the oxyhydrogen bacteria come from the cathodic and the iron bacteria from the anodic parts of the iron surface where, respectively, corrosion hydrogen is developed and iron is dissolved electrochemically to the ferrous state. Naturally, oxyhydrogen and iron bacteria are both present in the rust because of their close proximity on the cathodic and anodic areas.

It should be kept in mind that the cathodic and anodic behavior of the iron surface is related to the ever-present microelements—such as cathodic iron particles, which through some physical-chemical cause may be either more or less active than the particles acting as anodes—whereas the areas as a whole behave as cathodic and anodic macroelements.

Two comparative experiments can be separated into a chemical and a biochemical anodic reaction (Fig. 2 and 3). The cathodic action of the corrosion element becomes poor and stops if insufficient oxygen is admitted for the oxidation of the cathodic hydrogen and the consequent depolarization. The cathodes of the corrosion elements present on the so-called anodic iron surface are gradually polarized, become inactive, and are replaced by other active elements from the vicinity.

As a result of the gradually increasing size of the tubercle, its internal aeration decreases continuously. This decrease in aeration is aided by the need for oxygen of the iron bacteria at the surface of the tubercle, where the upward diffused anodic ferrous solute is oxidized to ferric hydroxide.

Whenever an impediment of oxygen takes place, the differential aeration principle of Evans (*1; 2*, p. 100) operates, and the anodic metal area increases at the cost of the cathodic area. The effect of the Evans principle is greatest when the oxygen consumption is large enough to cause an anaerobic condition within the tubercle, while aeration of the surrounding iron surface remains unhindered. Pasteur (*3*) had already called attention to the fact that aerobic organisms protect anaerobes—that is, the aerobic organisms produce the conditions for anaerobes to exist. This principle is applicable to rust tubercles if the aerobic iron bacteria can produce a favorable condition conducive to the development of anaerobic organisms. The sulfate-reducing spirillum, *Desulfovibrio desulfuricans*, found inside the tubercles can obtain the necessary soluble physiological sub-

stances, as well as the sulfates, from the tap water.

It is feasible to explain the internal corrosion of iron pipes on the basis of the following concepts:

1. The presence of chemoautotrophic oxyhydrogen bacteria in tap water leads to accumulation of bacterial material on the cathodic iron surface through the catalytic oxidation of corrosion hydrogen.

2. The presence of chemoautotrophic iron bacteria that oxidize the ferrous iron catalytically to ferric hydroxide, which together with the iron bacteria, accumulate on the anodic iron surface and later on the surface of the tubercle.

3. The biochemical oxygen depletion of the water at the surface of the tubercle, which may be so intensive that an internal anaerobic condition prevails.

4. The presence of sulfate-reducing spirilla capable of sulfate reduction within the tubercles under an anaerobic condition.

5. The iron corrosion in the pipe, started as an aerobic process, can be continued anaerobically by means of sulfate reduction, whereby the corrosion hydrogen is oxidized by the sulfate oxygen.

It has been indicated above that the cathodes of the microelements present on the iron surface covered by the tubercles become inactive through polarization. If the polarization hydrogen is oxidized by the sulfate-reducing spirilla with the aid of the oxygen from the sulfates, however, the cathodic action is restored and anaerobic iron corrosion again proceeds (*17*).

Investigation shows that the pH value of the moist corrosion product is greater than 7.0. There is no reason why there should be much variation from this pH value; hence, aerobic corrosion by oxyhydrogen bacteria and iron bacteria in tap water takes place at pH values above neutrality, similar to anaerobic iron corrosion through sulfate reduction.

Kooijmans (*21*), in his discussion of the chemistry of iron corrosion, indicates the relation between aerobic attack and the protective layer formed on the inside of clean iron pipes. He concludes that the precipitation of calcium carbonate is caused by the discharge of hydrogen ions against the clean pipe wall. When the resulting increase in alkalinity is slow, the calcium carbonate crystallizes, but when the increase in alkalinity is rapid, the calcium carbonate forms an amorphous precipitate, especially in soft waters. In nonaggressive waters, amorphous calcium carbonate is probably precipitated, whereas in waters having greater hardness, the precipitate may be crystalline, mixed with iron rust, which forms a protective layer. This reaction does not take place in soft water and hence no protective layer is formed. With increasing deposition of calcium carbonate and iron rust, the layer becomes denser and protection improves. This condition occurs in dune water. A lime-free protective coating may be formed when the calcium carbonate is replaced by ferrous carbonate.

Kooijmans (*21*) describes the purely chemical formation of protective layers during iron corrosion, but in studying internal iron corrosion and tubercle formation, the importance of biochemical reactions as well as purely chemical action must be considered. Attention has been called to the occurrence of irregularities in the iron during the production of iron pipe, not only through mechanical operations but also through temperature differences during cooling. Thus, from an electro-

chemical viewpoint, the pipe is predestined to contain cathodic and anodic areas which must lead to tubercle formation (*5, 22–24*).

Long ago the authors found dark colored masses in corrosion tubercles, sometimes a liquid containing ferrous sulfide. The presence of anaerobic sulfate-reducing spirilla can be shown easily when some of the corrosion material is used as inoculum in Beijerinck media and incubated at 30°C. The presence of sulfate-reducing bacteria in tubercles does not necessarily mean that they are active in the corrosion process, but the available substrate and the existing anaerobic condition are ecologically extremely favorable for accumulation of these bacteria.

Under the same conditions, graphitization takes place in external anaerobic corrosion of cast-iron pipe (*17*). The scalelike crusts and rust pocks, which, according to Kooijmans (*21*), are the result of corrosion by aggressive water, have been observed by the authors in iron pipe transporting noncarbon dioxide–aggressive water. The observed weak to strong tubercle formation, in which the carbon dioxide has no particular importance in tubercle formation but in which a low pH accelerates the corrosion, fits the author's views.

Brown (*9*), who discusses scale formation through iron rust, shows the layers in a cross section of an old tubercle, consisting of ferric hydroxide (formed into a resistant mass by iron bacteria, *Gallionella ferruginea*) and incrustations of calcium carbonate, a manganese dioxide, and other compounds, whereas the outer surface is covered by a layer of living iron bacteria. The core of the tubercle consists of a dark mass containing ferrous sulfide (FeS). Heymann (*5*) shows that a tubercle with a laminated crust has a cavity. Infrequently the authors have found the same thing, but the cavity is then filled with dark liquid.

The formation of the cavity in the tubercle can be explained in different ways:

1. By reduction of ferric hydroxide [$Fe(OH)_3$] from the tubercle with corrosion hydrogen, ferrous hydroxide [$Fe(OH)_2$] can be formed:

$$Fe(OH)_3 + H \rightarrow Fe(OH)_2 + H_2O$$

because ferric compounds are hydrogen acceptors. Through the excess of bicarbonate (HCO^-_3) ions in water the $Fe(OH)_2$ changes easily to the soluble iron bicarbonate [$Fe(HCO_3)_2$]:

$$Fe(OH)_2 + 2HCO^-_3 \rightarrow Fe(HCO_3)_2 + 2OH^-$$

which diffuses outward and is oxidized to $Fe(OH)_3$ at the surface of the tubercle. This reduction of $Fe(OH)_3$ in the tubercle may produce a cavity, because the solid ferric hydroxide disappears (*5*).

2. If sulfate reduction occurs in the tubercle, the following reaction takes place:

$$2Fe(OH)_3 + 3H_2S \rightarrow 2FeS + S + 6H_2O$$

$$FeS + S \rightarrow FeS_2$$

The voluminous $Fe(OH)_3$ is converted to FeS, S, and pyrites (FeS_2), which occupy less volume than the $Fe(OH)_3$ and hence a cavity is formed.

3. If a tubercle consists primarily of colloidal ferric hydroxide, the bound water is dependent upon the varying chemical combination. The compounds may change on aging and the phenomenon of syneresis or synergetic action may occur, whereby the original bound water is freed and the colloidal mass

contracts. The contracting colloidal mass separates from the iron surface and a cavity is formed. The cavity fills itself with liquid, darkly colored by the FeS, which is formed as a product of the anaerobic sulfate reduction process.

A combination of these three possibilities may cause cavities in tubercles. The size and extent of the tubercles on the internal iron surface may be appreciable and cause resistance to the water flowing in the pipe (*24*). Butlin (*22*) shows the size of a tubercle to be 154 × 101 mm and approximately 38 mm high, consisting primarily of hydrated ferrous-ferric-oxide mixed with ferric hydroxide. Bunker (*25*) indicates the presence of FeS in the tubercle, whereas the description by Reddick and Linderman (*26*) shows the probability of activity of sulfate-reducing bacteria in these tubercles. Bunker (*25*) found these bacteria together with quantities of FeS and surmised a relation between the bacteria and iron corrosion. Butlin (*22*), studying fresh tubercle contents, found 1.6 to 2.5 per cent S as FeS and 1,000 viable sulfate-reducing spirilla per milligram of corrosion product in the internal layers of the tubercles. The bacteria were autotrophic in character. It was further determined that serious graphitizing of the cast iron had taken place under the tubercles. These authors (*22, 25, 26*) came to the conclusion that the number of sulfate-reducing bacteria and the quantity of FeS in the corrosion product in the neighborhood of the iron were roughly the same as those obtained by anaerobic microbiological corrosion of the external surface of iron pipes. Hence, the activity of the sulfate-reducing bacteria was considered to be an important supplementary factor in the internal corrosion of water mains.

Schaeffer and Van der Woude (*23*) investigated the internal attack of a cast-iron pipe without bituminous coating. The internal surface of the pipe was covered with a red-brown rusty mass in the form of pimples, with alternating dark and light colored layers, and a black center. Under the pimples the iron was clearly graphitized. The black corrosion product had a hydrogen sulfide (H_2S) odor and, when exposed to air, changed to a light brown color. The samples of rust contained little, if any, FeS but, on the contrary, FeS_2. These authors (*23*) found that the moist rusty mass contained a large number of sulfate-reducing bacteria which could be cultured without difficulty in Van Delden media. They believed that the serious graphitization observed could not be the result of the small quantity (15 ppm) of sulfate present in the tap water. They also considered the alum used for coagulation a source of the sulfates. It is possible that when coagulation is ineffective, some flocculation occurs after the water leaves the filters and that the turbidity, containing sulfate, is deposited on the pipe wall. When this deposit reaches a certain thickness, the dissolved oxygen in the water cannot penetrate to the iron surface and the condition becomes more favorable for sulfate reduction. Attention is called to the fact that FeS_2 was present in the rust.

The senior author noted in another paper (*27*) that this polysulfide may be formed in a sulfate-reducing medium in the presence of $Fe(OH)_3$ (*see also 28*). This reaction may occur, therefore, in the anaerobic part of the tubercle, where H_2S develops and where, in the presence of $Fe(OH)_3$ the FeS_2 is precipitated by the iron bacteria. Pyrites (FeS_2) as well as

free sulfur (S), formed according to these reactions, are aggressive because they are corrosion-hydrogen acceptors. Free sulfur is particularly aggressive (*17*).

No previous study of internal iron corrosion has indicated the causative relation between aerobic corrosion (producing tubercles) and the anaerobic attack as a necessary result of the anaerobic condition in the center of the tubercle, which means the synthesis of both forms of iron corrosion. Intensively corroding iron water pipes induce aerobic and anaerobic action which is made possible by the hydrogen-oxidizing bacteria—the oxyhydrogen bacteria and sulfate-reducing spirilla—whereas activity of iron bacteria (if they are incapable of oxidizing hydrogen) is limited to the important secondary oxidation of ferrous to ferric iron.

It is not essential that the hydrogen bacteria complete aerobically or anaerobically the oxidation of corrosion-hydrogen, because the actual phenomenon is depolarization at the cathode of the corrosion element where the hydrogen formed is bound to an acceptor, which may be oxygen from the air or from the sulfate in the water. Viewed in this manner, the aerobic and anaerobic biochemical iron corrosion phenomena fall into a pattern wherein the depolarization process is the starting point and both corrosion processes form a natural, harmonious interrelated unity.

Conclusion

It is clear from the discussion presented that, from an economic standpoint, the cathodic and anodic areas of iron surfaces, which may be the result of metal stresses developed during production, must be made inactive by proper and effective internal protection.

References

1. Evans, U. R. The Electrochemical Character of Corrosion. *J. Inst. Metals*, **30**: 257 (1923).
2. ———. *The Corrosion of Metals.* Longmans, Green & Co., New York (1925).
3. Lafar, F. *Technical Mycology.* Griffin & Co., London (1911). Vol. 1, p. 577.
4. Gärtner, A. *Hygiene des Drinkwassers.* S. Karger, Berlin (1897).
5. Heymann, J. A. Aantasting en Vervuiling van Yzeren Waterleidingbuizen. *Wasser u. Gas*, **11**:32 (1926).
6. Beger, Herbert. The Biology of Iron Bacteria. *Gas- u. Wasserfach*, **80**:779 (1937).
7. Olsen, E., & Szybalski, W. Aerobic Microbiological Corrosion of Water Pipes. *Acta. Chem. Scand.*, **3**:1094, 1106 (1949).
8. Schorler, B. Beiträge zur Kenntnis der Eisenbakterien. *Zentr. Bakt. Parasitenk., Abt. II*, **12**:681 (1904); Die Rostbildung in den Wasserleitungsröhren. *Ibid.*, **15**:564 (1906).
9. Brown, J. C. Deposits in Pipes and Other Channels Conveying Potable Water. *Proc. Inst. Civ. Engrs.*, **156**:1 (1904).
10. Hermann, K. Verkrustungs- und Zerstörungserscheinungen im Leitungsnetz der Schwenningen Wasserversorgung. *Gas- u. Wasserfach*, **75**:890 (1932).
11. Minder, L. Zur Biologie der Wasserversorgungsanlagen. *Schweiz. Ver. Gas- u. Wasserfach Monats-Bul.*, **16**: 102 (1932).
12. Haase, L. W. *Werkstoffzerstorung u. Schutzschichtbildung im Wasserfach.* Verlag Chemie, Berlin (1944). p. 57; Corrosion by Cold and Hot Water. *Korrosion u. Metallschutz*, **15**:150 (1939); Effect of Biological Processes on the Destruction of Structural Materials. *Korrosion u. Metallschutz*, **16**:155 (1940).
13. Uhlig, Herbert H. *The Corrosion Handbook.* John Wiley & Sons, New York (1948). p. 480.
14. Winogradsky, S. Ueber Eisenbakterien. *Botan. Ztg.* (1880), p. 270.
15. Cholodny, N. Die Eisenbakterien—Beitrage zu Einer Monographie. In Kolkwitz, R., *Pflanzenforschung.* Dahlem, Berlin (1926). p. 1.

16. BENEDEN, G. VAN. Rust and Its Deposition in Water Mains From the Biological Point of View. *Bul. Centre Belge Etude et Documentation Eaux (Liege)*, **1**:11:64 (1951).
17. KÜHR, C. A. H. VON WOLZOGEN, & VAN DER VLUGT, L. S. The Graphitization of Cast Iron as an Electrobiochemical Process in Anaerobic Soils. *Water*, **18**:147 (1934).
18. KLUYVER, J. A., & MANTEN, A. *Antonie van Leeuwenhoek*, **8**:71 (1942).
19. CUSHMAN, A. S., & GARDNER, H. A. *The Corrosion and Preservation of Iron and Steel*. McGraw-Hill Book Co., New York (1910). p. 51.
20. LIEBREICH, E. *Rost und Rostschutz*. F. Vieweg & Sohn, Braunschweig (1914). p. 8–10.
21. KOOIJMANS, JOHANNES. Corrosion and Protective Coating Formation in Water Mains. *Gas- u. Wasserfach*, **81**:611, 628 (1938).
22. BUTLIN, K. R.; ADAMS, MARY E.; & THOMAS, MARGARET. Sulfate-reducing Bacteria and Internal Corrosion of Ferrous Pipes Conveying Water. *Nature*, **163**:26 (1949).
23. SCHAEFFER, C. O., & VAN DER WOUDE, C. A. A. Inwendige Aantasting von Waterleidungbuizen onder Medewerking von Sulfaatreducerende Bacteriën. *De Ingenieur in Indonesie*, **6**:2 (1950).
24. ATKINSON, A. The Relining of Water Mains in Situ. *Jour. Inst. Wtr. Engrs.*, **4**:4:293 (1950).
25. BUNKER, H. J. Microbiological Anaerobic Corrosion. *J. Soc. Chem. Ind.*, **59**:412 (1940).
26. REDDICH, H. G.; & LINDERMAN, S. E. Tuberculation of Mains as Affected by Bacteria. *Jour. NEWWA*, **46**:146 (1932).
27. KÜHR, C. A. H. VON WOLZOGEN. The Corrosion of Lead and Copper Water Pipes in the Soil. *Water*, **23**:215 (Dec. 15, 1939).
28. VERHOOP, J. A. D. Chemical and Microbiological Transformations of Iron Sulfides in Soil. Thesis, Leiden (1940). pp. 88, 90, 96.

NARUC Resolution on Relocation of Facilities

In its efforts to lift the burden of costs of changes in utility structures necessitated by highway projects, the AWWA is happy to acknowledge the support of the National Assn. of Railroad and Utilities Commissioners as expressed in this resolution, passed by the annual convention of NARUC at Little Rock, Ark., in November 1952:

WHEREAS, In these times of constantly increasing cost and ever higher taxes, regulatory commissions are especially concerned over increased operating costs of utilities that necessitate higher rates to the users of such service; now, therefore, be it

RESOLVED, That the National Association of Railroad and Utilities Commissioners is of the opinion that the existing discrimination against nonrailroad utilities should be eliminated and that equal treatment should be accorded all utilities having facilities involved in federal-aid highway projects, and

RESOLVED FURTHER, That the committee on legislation and the legal representatives of this association are authorized to appear on behalf of the association before any committee of Congress at any hearing which may be hereafter held upon legislation pertaining to the above matter for the purpose of presenting the views of this association.

Effect of Free Residual Chlorination on Nitrogen Compounds in Water

By Michael J. Taras

A contribution to the Journal by Michael J. Taras, Research San. Chemist, Detroit Dept. of Water Supply, Dearborn, Mich.

ALTHOUGH free residual chlorination is an established practice in the water purification field, much of the fundamental knowledge about this treatment remains to be formulated. It is recognized that the nitrogen content of a water exerts a considerable influence on the chlorine demand. Most of the literature heretofore has dwelt upon the reaction between ammonium nitrogen and chlorine. Pertinent work on organic nitrogen compounds is meager (*1, 2*). Many surface waters contain little ammonium ion but exhibit significant chlorine demand. The albuminoid nitrogen in these waters is an important factor in the chlorine demand of the water. The Detroit water supply falls into this class (*3*).

A previous paper (*4*) pointed out the relationship between the albuminoid nitrogen content and the experimental 15-min free-chlorine demand of the amino acids. The inference at the time was that the albuminoid nitrogen was being attacked in some way by chlorine treatment. All conclusions were based on the determination of chlorine absorption alone. A study of the nitrogen factor after chlorination resulted as the natural outgrowth of these previous studies.

Three analyses for nitrogen are available to the water chemist—ammonium, albuminoid, and total nitrogen (*5*). A truer picture of the effect which chlorination exerts on organically bound nitrogen can be obtained if all three nitrogen forms are determined at the same time. Because of the complexity of the chlorination reaction, the favoring of one of the analyses may give a distorted picture. Essentially the same reasoning applies to the selection of organic compounds for investigation. A comprehensive sampling of organic substances must be undertaken if a pattern is to be established. Generalizations based on isolated examples of erratically behaving compounds, innocently selected, can be misleading.

Nitrogen Studies

To assure that any conclusions drawn from the experimental results would be valid, a preliminary check of the analytical procedures for accuracy and precision was necessary. Sample volumes of the size contemplated for use throughout the study were prepared in various known concentrations with ammonium chloride, and the recoveries were noted. The Kjeldahl digestion-distillation method yielded substantially quantitative recoveries. On the other hand, the distillation method for ammonium nitrogen afforded recoveries of approximately 85–90 per cent, and a supplemental 5–10 per cent distilled over in the albuminoid nitrogen fraction made a total nitrogen recovery of approximately 95 per cent.

Previous work (*4*) had disclosed that the albuminoid nitrogen values were approximately 80 per cent of the total nitrogen analyses of the simpler straight-chain amino acids. The conversion of an unsubstituted amino group to the ammonium ion by the alkaline potassium permanganate reagent may be incomplete because of complicating side reactions, or because of the substantial volumes that are handled. This reasoning is borne out by the findings for ammonium recoveries. These limitations must be kept in mind when absolutes are considered. Until a better procedure is developed, the alkaline potassium permanganate reagent serves a useful purpose in demonstrating the effect which chlorination exerts on some amino groups. On account of the acknowledged shortcomings of the albuminoid nitrogen determination, initial nitrogen concentrations in excess of 0.25 ppm were used in these experiments; the majority of the nitrogen concentrations exceeded 0.3 ppm. Thus, it was hoped to make any effect of chlorination evident in spite of the known deficiencies of the albuminoid nitrogen determination.

Experimental

All amino acid and protein standard solutions were prepared with chlorine demand–free distilled water (*4*). For the few difficultly soluble amino acids and proteins, a minimum volume of 20 per cent sodium hydroxide was added to facilitate solution. These standard solutions were added in the desired quantities to the buffered, chlorine demand–free water, and the final total volume was usually brought to 8,500 ml. After thorough mixing, exactly 750 ml was withdrawn for the ammonium and albuminoid analyses, and 500 ml for the total nitrogen determination. Another 250 ml was removed for miscellaneous pH and conductance measurements. The remaining 7.0 liters was dosed with chlorine water containing between 0.5 and 1.0 mg of chlorine per milliliter. After the indicated contact times of 1 and 24 hours, two 1.5-liter portions were withdrawn, one portion being treated with minimal volumes of 0.1*N* sodium thiosulfate and the other with an arsenous type of dechlorinating agent. No more of this agent was used than was absolutely necessary to effect chlorine removal. Ammonium and albuminoid nitrogen analyses were run on 750 ml of each dechlorinated sample and total nitrogen was determined on a separate 500-ml volume. Standard reagents (*5*) were used throughout.

A sample volume of 750 ml was selected for the combined ammonium and albuminoid determinations because of the necessity for collecting two successive fractions totaling 450 ml of distillate. This volume facilitated a smooth distillation and avoided the bumping encountered with smaller samples.

Distillate volumes included 100 or 200 ml for ammonium nitrogen, 250 ml for albuminoid nitrogen, and 200 ml for total nitrogen. All collections were made in volumetric flasks, and distillates were warmed to room temperature before nesslerization. A 50-ml aliquot was nesslerized and the transmittance of the colored solution was measured in the 5- or the 1-cm light path of a photometer.* A blue color filter exhibited maximum absorption near 410 mμ. Inasmuch as all nitrogen concentrations were distilled from larger sample quantities to a reduced volume, it was possible to determine with con-

* A Cenco-Sanford-Sheard Photelometer, a product of the Central Scientific Co., Chicago, was used.

fidence nitrogen levels as low as 0.02 ppm with a reproducibility of 0.02 ppm.

The experimental conditions were set up so that the results would provide useful clues to sewage pollution in Detroit's water supply. Accordingly, the amount of sodium bicarbonate used for buffering the chlorine demand–free distilled water in the amino acid phase of this investigation was sufficient to produce a pH between 7.5 and 8.0 and a specific conductance of approximately 210 micromhos at 25°C.

All samples were maintained for the required time interval in a constant-temperature incubator set at 23°C, the temperature which corresponded to the average attained by the Detroit supply during the summer season when the effect of temperature on chlorine demand is greatest. Except for the obvious modifications, all natural waters and sewage dilutions were handled in a similar manner.

Chlorine doses which insured a free available chlorine residual of at least 0.5 ppm after 24 hours, or at the end of any longer contact period of experimentation, were applied. Only free available chlorine residuals were measured by procedures previously described (*4*). Glass-stoppered pyrex bottles were used for all chlorination work. Chromic acid cleaning and hot-air sterilization afforded indispensable safeguards against interference from unknown contaminants.

Dechlorinating Agents

Four dechlorinating agents—sodium thiosulfate, sodium sulfite, sodium arsenite, and phenylarsene oxide—were investigated in preliminary trials to ascertain which would be the most suitable. The total nitrogen recoveries on β-alanine, *dl*-aspartic acid, *dl*-leucine, glutathione, and neopeptone, following dechlorination with each of the four dechlorinating agents, agreed within 0.02 ppm. As no radical differences were noted among the four dechlorinating agents, much of the subsequent work was confined to sodium thiosulfate, which is representative of the sulfur type of dechlorinating agent, and to sodium arsenite and phenylarsene oxide, which are representative of the arsenous dechlorinating agents.

As a result of these experiments, the procedure adopted consisted of withdrawing two portions of 1.5 liters each of chlorinated sample after the specified contact period of 1 and 24 hours, and dechlorinating one portion with increments of 0.2 ml of 0.1*N* sodium thiosulfate until no yellow color was obtained with orthotolidine reagent when a small dechlorinated sample was tested. Usually less than 1.0 ml of 0.1*N* sodium thiosulfate was sufficient. One of the arsenous reagents was used for dechlorinating the second portion. Sodium arsenite and sodium sulfite were employed in 0.5 or 1 per cent concentration whereas 0.01*N* phenylarsene oxide was used. Dechlorinations were accomplished in the shortest interval possible, usually within 15 min.

Nitrogen Demand of Organic Materials

Many factors enter into the study of a subject as complicated as chlorination. Molecular structure ranks high in importance. The molecular architecture of an amino acid exerts a considerable effect on the course of chlorination, and influences the results obtained with any particular set of analytical methods employed in the investigation. An amino acid like α-aminoisobutyric acid chlorinates in much the same manner as its chemical homologs, yet fails to respond in the expected way to the albuminoid nitrogen determination. On the other hand,

TABLE 1

Albuminoid Nitrogen Losses Following Chlorination

Compound*	Albuminoid Nitrogen Added *ppm*	Albuminoid Nitrogen Recovered—*ppm*		Albuminoid Nitrogen Reduction After 24 hr *per cent*
		1-hr Chlorination†	24-hr Chlorination†	
Aliphatic compounds				
Glycine	0.34	0.04	0.01	90+
β-Alanine	0.33	0.02	0.02	90+
dl-α-Amino-*n*-butyric acid	0.51	0.07	0.01	90+
dl-α-Amino-*n*-valeric acid	0.38	0.02	0.01	90+
dl-Valine	0.45	0.04	0.01	90+
dl-Leucine	0.42	0.03	0.02	90+
dl-Isoleucine	0.41	0.04	0.01	90+
dl-α-Aminocaprylic acid	0.24	0.04	0.01	90+
dl-Serine	0.53	0.04	0.02	90+
dl-Threonine	0.44	0.04	0.01	90+
l-(+)-Glutamic acid·HCl	0.29	0.05	0.04	80–90
dl-Aspartic acid	0.27	0.05	0.06	70–80
δ-Amino-*n*-valeric acid·HCl	0.25	0.20	0.06	70–80
dl-Lysine·2HCl	0.34	0.21	0.19	40–50
Creatine (hydrate)	0.35	0.27	0.21	30–40
ε-Amino-*n*-caproic acid	0.41	0.39	0.28	30–40
Sulfur compounds				
dl-Methionine	0.26	0.04	0.02	80–90
Cysteine·HCl	0.33	0.07	0.04	80–90
l-(−)-Cystine	0.25	0.13	0.09	60–70
Taurine	0.38	0.36	0.34	−10
Glutathione	0.43	0.42	0.39	−10
Cyclic compounds				
Glycine anhydride	0.46	0.33	0.07	80–90
l-(−)-Tryptophane	0.29	0.13	0.09	60–70
l-(−)-Tyrosine	0.23	0.13	0.12	40–50
l-(+)-Histidine·HCl·H_2O	0.37	0.27	0.21	40–50
Creatinine	0.33	0.31	0.29	10–20
Polypeptides and proteins				
Tryptone‡	0.31	0.21	0.18	30–40
Neopeptone‡	0.36	0.29	0.24	30–40
Zein (corn protein)§	0.33	0.30	0.23	30–40
Casein	0.27	0.24	0.19	20–30
Lactalbumin§	0.26	0.24	0.20	20–30
Gelatin‡	0.35	0.30	0.27	20–30
Manganese peptonate‖	0.27	0.25	0.22	10–20

* All amino acids were products of Eastman Kodak Co., Rochester, N. Y.

† Dechlorinations were accomplished with sodium thiosulfate and sodium arsenite or phenylarsene oxide. The value obtained with each dechlorinating agent agreed within 0.01 ppm of the average which is presented in the table.

‡ Products of Difco Laboratories, Detroit, were used.

§ Products of General Biochemicals, Inc., Chagrin Falls, Ohio.

‖ A product of Merck & Co., Rahway, N. J., was used.

the albuminoid nitrogen determination yields experimental values closer to the theoretical nitrogen content of piperidine than the strikingly low values given by the Kjeldahl method in the absence of selenium–mercuric oxide catalysts. Accordingly, conclusions drawn from these studies must, of necessity, be general in nature and cannot be interpreted too strictly. General patterns, however, are evident, and warrant special note.

The chlorination of the simpler and unsubstituted amino acids results in a relatively rapid conversion of the amino group to a chemical form subsequently undetectable as albuminoid nitrogen. Much of this conversion of albuminoid nitrogen may take place within the first hour (Table 1). Although the loss of total nitrogen attending chlorination may sometimes be appreciable, it seldom exceeds 75 per cent of the original concentration, even when the albuminoid nitrogen is largely dissipated (Table 2).

At the opposite pole is the group of complex organic materials known as proteins. The amount of nitrogen transformation attendant upon their chlorination is slight. The albuminoid and total nitrogen analyses both reveal the reduced reactivity of this body of nitrogenous substances. Glutathione provides an example of the type of nitrogen demand manifested by this class of substances.

In sharp contrast is the ammonium ion, which loses almost 90 per cent of its identifiable nitrogen under the same conditions of pH, temperature, and contact time. The ratios of free chlorine consumed to total nitrogen are also considerably greater for many organic compounds than for ammonium ion (Table 3).

Like the free-chlorine demand, the total nitrogen demand of the amino acids frequently proved to be an exponential function of time. The exponential nature of the data was demonstrated on several representative amino compounds which were measured over contact periods up to 72 hours.

The mathematical expression developed previously (*3*, *4*, *6*) for calculating the free-chlorine demand applies equally well to the nitrogen demand of many organic compounds. Both chlorine and nitrogen demands may be expressed mathematically by the general equation, $D = kt^n$, where D is the free available chlorine or total nitrogen consumed (parts per million) after t hours, k is the constant representing the free available chlorine or total nitrogen consumed (parts per million) after a contact period of 1 hour, and n is the velocity constant. The constants k and n are characteristic of the nitrogenous material being chlorinated. Generally speaking, the simpler, unsubstituted amino acids gave minimum exponential values whereas the more complicated compounds tended toward maximum values. Ammonium ion yielded the lowest exponents for both chlorine and nitrogen demands.

A tabulation of nitrogen exponential values is deliberately withheld because they cannot be regarded as absolutes since they were derived from experimental results obtained at only two different hours. Errors, which are inevitable in every experiment, could reflect enormously in the calculation of the exponential constants. Only in those examples cited in the graphs are definite values offered, and then merely to show the nature of the curves. The exponents are relative and, therefore, intended solely as guides.

A sounder procedure is the offering of experimental findings (Tables 1 and 2), thus averting unwarranted conclu-

TABLE 2

Total Nitrogen Losses Following Chlorination

Compound*	Total Nitrogen Added *ppm*	Total Nitrogen Recovered—*ppm*		Total Nitrogen Reduction After 24 hr *per cent*
		1-hr Chlorination†	24-hr Chlorination†	
Aliphatic compounds				
Glycine	0.43	0.32	0.08	50+
β-Alanine	0.48	0.25	0.20	50+
dl-α-Amino-*n*-butyric acid	0.57	0.32	0.27	50+
dl-α-Amino-*n*-valeric acid	0.43	0.21	0.18	50+
dl-Valine	0.50	0.32	0.22	50+
dl-Leucine	0.44	0.18	0.12	50+
dl-Isoleucine	0.46	0.25	0.19	50+
dl-α-Aminocaprylic acid	0.28	0.20	0.13	50+
dl-Serine	0.30	0.20	0.12	50+
dl-Threonine	0.24	0.17	0.07	50+
Creatine (hydrate)	1.97	1.69	0.96	50+
dl-Aspartic acid	0.44	0.35	0.32	20–30
Urea	0.50	0.47	0.46	−10
l-(+)-Glutamic acid·HCl	0.33	0.32	0.31	−10
dl-Lysine·2HCl	0.37	0.35	0.35	−10
δ-Amino-*n*-valeric acid·HCl	0.32	0.32	0.32	−10
ε-Amino-*n*-caproic acid	0.43	0.42	0.43	−10
Sulfur compounds				
dl-Methionine	0.45	0.38	0.31	30–40
Cysteine·HCl	0.28	0.22	0.19	20–30
l-(−)-Cystine	0.41	0.38	0.30	20–30
Taurine	0.70	0.67	0.67	−10
Glutathione	0.81	0.80	0.77	−10
Cyclic compounds				
Uric Acid	0.63	0.33	0.17	50
Glycine anhydride	0.46	0.45	0.22	40–50
l-(−)-Tryptophane	0.40	0.36	0.24	30–40
l-(+)-Histidine·HCl·H_2O	0.63	0.60	0.48	20–30
l-(−)-Tyrosine	0.34	0.30	0.27	10–20
Creatinine	1.65	1.63	1.33	10–20
Polypeptides and proteins				
Manganese peptonate‡	0.77	0.74	0.61	20–30
Tryptone§	0.59	0.55	0.51	10–20
Neopeptone§	0.84	0.82	0.73	10–20
Gelatin§	0.84	0.80	0.73	10–20
Casein	0.82	0.81	0.72	10–20
Lactalbumin‖	1.06	1.05	0.93	10–20
Zein (corn protein)‖	1.15	1.14	1.06	−10

* All amino acids were products of Eastman Kodak Co., Rochester, N. Y.
† Dechlorinations were accomplished with sodium thiosulfate and sodium arsenite or phenylarsene oxide. The value obtained with each dechlorinating agent agreed within 0.01 ppm of the average which is given in the table.
‡ A product of Merck & Co., Rahway, N. J., was used.
§ Products of Difco Laboratories, Detroit, were used.
‖ Products of General Biochemicals, Inc., Chagrin Falls, Ohio, were used.

TABLE 3

Chlorine-Nitrogen Relationship of Various Substances

Compound*	Chlorine Dose *ppm*	Free Chlorine Consumed After 1 hr *ppm*	Total Nitrogen *ppm*	Ratio of 1-hr Free Chlorine Consumed to Total Nitrogen
l-(−)-Tyrosine	20.0	15.0	0.39	38:1
Cysteine·HCl	9.00	7.18	0.27	27:1
l-(−)-Cystine	11.5	9.06	0.35	26:1
dl-Tryptophane	14.5	9.70	0.41	24:1
dl-Methionine	12.5	8.35	0.38	22:1
Glycine	10.5	7.40	0.37	20:1
dl-Threonine	15.0	7.55	0.47	16:1
dl-Aspartic acid	6.50	4.50	0.32	14:1
l-(+)-Glutamic acid·HCl	6.50	3.20	0.23	14:1
dl-Serine	10.5	6.63	0.53	13:1
β-Alanine	5.50	4.05	0.32	13:1
dl-Lysine·2HCl	6.00	4.60	0.38	12:1
dl-Leucine	5.00	3.75	0.32	12:1
α-Aminoisobutyric acid	7.00	4.38	0.41	11:1
ε-Amino-*n*-caproic acid	9.00	4.57	0.43	11:1
dl-α-Amino-*n*-valeric acid	6.25	4.13	0.36	11:1
dl-Valine	7.00	5.20	0.48	11:1
dl-α-Amino-*n*-butyric acid	6.25	5.80	0.54	11:1
dl-α-Aminocaprylic acid	4.00	2.70	0.26	10:1
Taurine	8.50	6.95	0.67	10:1
Ammonium chloride	11.0	9.06	1.00	9:1
Glutathione	11.0	7.26	0.82	9:1
Uric acid	12.5	6.17	0.67	9:1
Trypto·e†	5.00	3.32	0.59	6:1
l-(+)-Histidine·HCl·H_2O	7.00	3.06	0.60	5:1
Neopeptone†	6.00	3.63	0.77	5:1
Casein	6.00	2.20	0.82	3:1
Creatine (hydrate)	12.0	5.90	2.25	3:1
Lactalbumin‡	7.50	2.83	1.06	3:1
Manganese peptonate§	6.00	2.53	0.77	3:1
Creatinine	7.25	3.85	1.85	2:1
Gelatin†	8.50	1.27	0.72	2:1
Zein (corn protein)‡	7.50	2.43	1.15	2:1

* All amino acids were products of Eastman Kodak Co., Rochester, N. Y.
† Products of Difco Laboratories, Detroit, were used.
‡ Products of General Biochemicals, Inc., Chagrin Falls, Ohio, were used.
§ A product of Merck & Co., Rahway, N.J., was used.

sions from the data. In this way, the general pattern, together with the exceptions, is made evident. Calculations sometimes obscure rather than clarify the overall picture. The author's principal objective was to observe whether the nitrogen demand exponents matched the chlorine demand exponents. Frequently the exponents were found to vary, offering nonparallel lines when the demand data were plotted logarithmically against contact time.

Chlorine and Nitrogen Demands of Sewage Pollution

Drawn from the lower reaches of Lake St. Clair, the Detroit raw supply is subject to the natural purification

processes that take place in such a sizable body of water. As a result, the concentration of ammonium ion and simple amino forms is usually small.

The complex structure of proteins, which have amino and other groups, makes these materials among the hardest to decompose by chlorination. Unless polluted by sewage components, Detroit raw water normally shows minor losses of total nitrogen and albuminoid nitrogen following chlorination.

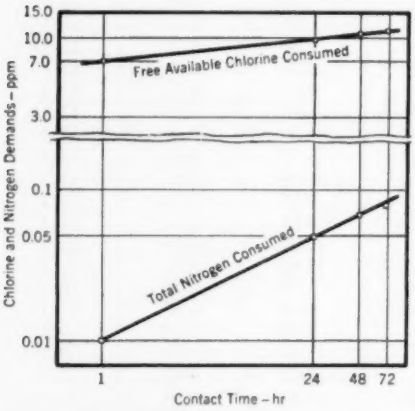


Fig. 1. Chlorine and Nitrogen Demands of 6.0 ppm Glutathione

The total nitrogen consumed in ppm = 0.01 (time in hours)$^{0.49}$. The free available chlorine consumed in ppm = 7.08 (time in hours)$^{0.10}$. The chlorine dose was 12.0 ppm.

Among the amino acids, the nitrogen demand pattern of glutathione approximates that observed in the Detroit supply. (The implication that glutathione is a constituent of Detroit water is not intended or warranted on this evidence; only patterns are under discussion.) The tripeptide structure of glutathione bears a very simplified resemblance to a protein. These linkages respond to chlorination by giving variable chlorine and nitrogen demand exponential and first-hour constants. In other words, the chlorine and nitrogen demand lines are not parallel when consumption is plotted logarithmically against contact time (Fig. 1). The albuminoid nitrogen reduction attendant upon chlorination is also negligible. Thus, glutathione serves as the model of a compound which resists nitrogen degradation following chlorination, a phenomenon encountered in some surface supplies.

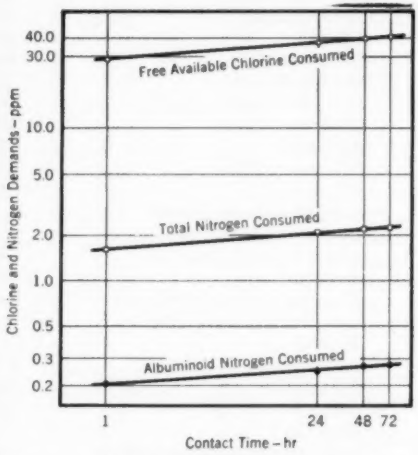


Fig. 2. Chlorine and Nitrogen Demands of Sewage in Detroit Raw Water

The albuminoid nitrogen consumed in ppm = 0.21 (time in hours)$^{0.07}$. The total nitrogen consumed in ppm = 1.62 (time in hours)$^{0.08}$. The free available chlorine consumed in ppm = 2.90 (time in hours)$^{0.08}$. The chlorine dose was 40.0 ppm, and the initial ammonium nitrogen 1.52 ppm, albuminoid nitrogen 0.65 ppm, and total nitrogen 3.49 ppm. The sewage concentration was 30 per cent by volume.

On the basis of nitrogen content, Detroit sanitary sewage at 7 AM, the sampling time for this work, could be classified as weak (7). Chemical analyses indicated that industrial wastes

were at a minimum. The ammonium and albuminoid nitrogen concentrations frequently accounted for 75 per cent or more of the initial chlorine demand (*4*). Many sewage dilutions exhibited demand patterns typical of these two principal chlorine-consuming classes of substances. The ammonium ion exerted a preponderant and speedy effect on the immediate chlorine demand, being succeeded by the more slowly acting organic constituents. The ratio of these two classes present in the sewage dilution affected the rate of nitrogen decline with respect to time; the organic ingredients were recognizable by a continuous nitrogen demand.

A simple but definite relationship between the chlorine and nitrogen demands in the majority of the sewage samples tested was evident. Inspection of Fig. 2 discloses that parallel lines resulted when the chlorine and nitrogen demand data were plotted logarithmically against contact time. Thus, given the ratio of chlorine consumed to total nitrogen consumed at any particular hour, it was possible to compute with a fair degree of accuracy the demand of either the free available chlorine or the total nitrogen at any subsequent time with the aid of one additional measurement. As the chlorine determination can be conveniently performed, a quick estimate of the probable loss of total nitrogen at any hour can be made.

The parallel lines displayed by the 30 per cent sewage concentrations in Fig. 2 illustrate the effect which mounting sewage doses exerted on Detroit raw water. The chlorine and nitrogen demand curves of the 1.5 per cent sewage dilutions in Detroit raw water are often nonparallel, like those shown in Fig. 1. The explanation for this variation is the chemical composition of the sewage dilutions. At the lower sewage concentrations, the albuminoid content of the raw water, which served as the diluent, often exceeded the ammonium ion concentration, thereby controlling the course of chlorination. The demand lines provided by many amino compounds are nonparallel. As the ammonium ion concentration increased through sewage application, the lines tended to become parallel. The parallel effect was evident when the sewage strength approached 5 per cent in Detroit raw water. It should be emphasized that the typical parallel effect was achieved in 1.5 per cent sewage concentrations when buffered, chlorine demand–free distilled water was the diluting agent.

From a practical standpoint, precipitation in the Detroit metropolitan area was found to affect the character of the sewage composition. On such occasions, the rain or snow diluted the sewage before it arrived at the plant, reducing the ammonium load by a significant amount. The parallel effect at sewage concentrations up to 30 per cent was absent on some of these days. The dissimilarity in the exponential values is shown in Table 4.

Chlorine and Nitrogen Demand of Known Sewage Components

The divergent chlorine and nitrogen demand lines given by glutathione are more typical of the many amino acids tested than they are of uric acid. The uric acid lines are illustrated in Fig. 3 because the compound, like urea, is a known, although minor, constituent of urine.

The study of the amino acids proved valuable in explaining the deviations from parallelism observed in some of the sewage dilutions. The logarithmic plot of the chlorine and nitrogen demand of many amino acids against contact time yields straight lines having

different slopes. Figure 3 shows the parallel nature of the ammonium ion and uric acid lines. As the Detroit sewage samples contained significant amounts of ammonium ion, the slope of the lines followed this standard parallel pattern. When the ammonium ratios were comparatively low, usually on rainy or snowy days, the nonparallel character of the amino acid and protein lines became dominant. On such days the organic agents were important factors in the chlorine and nitrogen demands.

TABLE 4

Chlorine and Nitrogen Demand Data on Sewage Dilutions in Detroit Raw Water

Date	Sewage Dilution *per cent*	n Exponent*		k 1-hr Demand* *ppm*		Nitrogen Analyses—*ppm*			Ratio of k (for Cl) to Total N
		Cl	N	Cl	N	NH_3	Albuminoid	Total	
10/23/51†	5	0.10	0.24	5.03	0.15	0.12	0.18	0.69	7:1
11/13/51	10	0.07	0.14	10.0	0.31	0.24	0.27	0.98	10:1
11/20/51	5	0.07	0.06	6.71	0.35	0.33	0.20	0.84	8:1
11/27/51	10	0.06	0.07	12.3	0.66	0.62	0.28	1.35	9:1
12/4/51†	5	0.08	0.23	5.80	0.21	0.23	0.15	0.65	9:1
12/27/51	5	0.06	0.09	6.29	0.32	0.33	0.14	0.73	9:1
1/3/52†	10	0.07	0.23	9.84	0.38	0.39	0.22	1.09	9:1
1/8/52	5	0.07	0.08	6.12	0.27	0.26	0.13	0.69	9:1
1/15/52	10	0.16	0.18	7.75	0.18	0.19	0.26	1.03	8:1
2/5/52†	10	0.09	0.22	9.26	0.29	0.30	0.23	1.07	9:1
2/12/52	15	0.06	0.08	15.8	0.78	0.74	0.33	1.78	9:1
2/19/52	20	0.04	0.05	23.9	1.38	1.41	0.53	2.83	8:1
2/26/52	25	0.04	0.05	31.3	1.76	1.66	0.83	3.63	9:1
3/4/52	30	0.10	0.11	27.4	1.04	1.08	0.78	2.96	9:1
3/11/52†	30	0.21	0.30	10.7	0.24	0.25	0.31	1.30	8:1
3/18/52	30	0.06	0.05	35.0	2.06	2.02	0.65	3.84	9:1
3/25/52	30	0.11	0.12	28.2	1.46	1.36	0.66	3.43	8:1
4/1/52	30	0.07	0.07	30.8	1.97	1.70	0.75	3.84	8:1
4/8/52	30	0.08	0.08	29.2	1.62	1.52	0.65	3.49	8:1
4/15/52	30	0.12	0.10	22.6	1.14	1.04	0.48	2.75	8:1
4/21/52	15	0.08	0.09	17.8	0.89	0.82	0.46	2.13	8:1

* Values for equation $D = kt^n$.
† Rain or snowfall before sewage sampling.

Ammonium Determination

Free residual chlorination exerted a singular effect on many amino acids, as revealed by the ammonium, albuminoid, and total nitrogen analyses. Following dechlorination, the analysis for ammonium ion by the distillation method yielded a bright off-color yellow in the nesslerized distillates of most samples. The color resembled that produced by the nesslerization of simple aliphatic amines. Less frequently an opalescent, colloidal turbidity resulted upon nesslerization. These latter effects were associated principally with those compounds—sarcosine, creatine hydrate, and serine—which formed high chloramine concentrations in conjunction with the normal free chlorine and nitrogen trichloride residuals. In fact, monochloramine and dichloramine re-

siduals, apparently of an organic nature, totaling more than 1 ppm could be demonstrated in some of the offending distillates by amperometric titration and by the yellow color that developed when the standard orthotolidine reagent was used. The off colors were duplicated in dechlorinated sewage dilutions having concentrations greater than 5 per cent by volume.

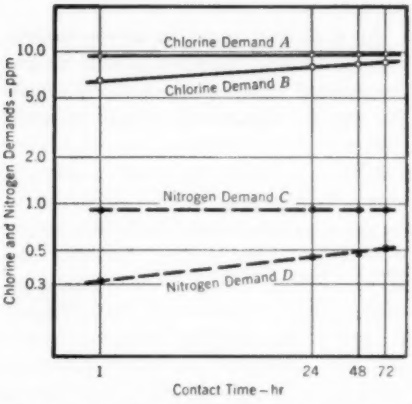


Fig. 3. Chlorine and Nitrogen Demands of Two Sanitary Sewage Components

Chlorine demand B *and nitrogen demand* D *of 2.0 ppm uric acid. Chlorine demand* A *and nitrogen demand* C *of 1.0 ppm ammonium nitrogen added as ammonium chloride. The chlorine dose for uric acid was 9.5 ppm and for ammonium nitrogen 11.0 ppm.*

Chlorine and Nitrogen Demands of Natural Waters

Fortunately, the pollution of Detroit surface supplies has never approached a magnitude at which nitrogen losses equal free-chlorine losses. Considerable sanitary pollution would be necessary to overcome the dominant proteinaceous nature of Detroit water to produce a parallel effect. On the few occasions in recent years when abnormal pollution has entered the supply, the chlorine and nitrogen demand curves approximated those obtained with sewage concentrations approaching 1 per cent by volume, the contaminants consisting primarily of ammonium and albuminoid nitrogen.

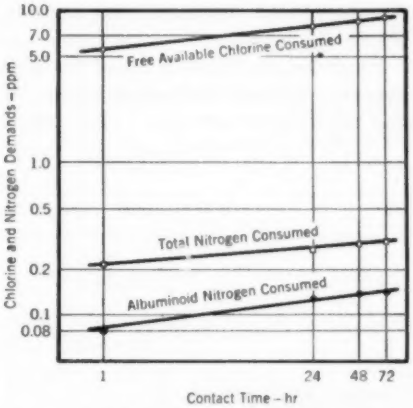


Fig. 4. Chlorine and Nitrogen Demands of Mt. Clemens Raw Water

The albuminoid nitrogen consumed in $ppm = 0.08\ (time\ in\ hours)^{0.14}$. *The total nitrogen consumed in* $ppm = 0.22\ (time\ in\ hours)^{0.09}$. *The free available chlorine consumed in* $ppm = 5.65\ (time\ in\ hours)^{0.11}$. *The chlorine dose was 9.0 ppm, and the initial ammonium nitrogen 0.14 ppm, albuminoid nitrogen 0.28 ppm, and total nitrogen 0.74 ppm.*

The Mt. Clemens supply, which is drawn from upper Lake St. Clair, on the other hand, is exposed to more frequent and more serious nitrogen pollution. Figure 4 illustrates the parallel free chlorine and total nitrogen demands exerted by a sample of this surface supply collected on June 6, 1952, which contained relatively high levels of ammonium ion, albuminoid nitrogen, and total nitrogen. The Mt. Clemens

lines bore a striking similarity to the lines offered by sewage dilutions.

Ground Water

The major portion of the iron content of the well waters was removed by filtering through filter paper after precipitation had occurred on standing. Thus, a relatively small amount of dissolved iron remained in solution before chlorination.

As shown in Table 5, all of the well waters contained both ammonium ion and albuminoid nitrogen. The traces of albuminoid nitrogen present in the Avon Road and Rochester Road well supplies, and the concurrent high ammonium content, however, confirmed a fact established in synthetic solutions —namely, the incomplete recovery of the ammonium fraction in the first distillate. If the recovery of the ammonium fraction before chlorination is corrected by multiplying by 1.1, a factor experimentally derived using synthetic solutions, much of the albuminoid nitrogen distillate can safely be regarded as ammonium ion. These conclusions are supported by the chlorine demand exponential constants of these well supplies which approach the minimum values—0.01—characteristic of the ammonium ion. This finding emphasizes the advisability of performing the ammonium and albuminoid analyses in sequence to obtain a proper perspective of the ammonium nitrogen factor.

An examination of the nitrogen analyses of the well supplies (Table 5) and the sewage dilutions (Table 4) shows the ample ammonium content of each. It is not surprising, therefore, that the same parallel effect noted in the chlorine and nitrogen demands of the sewage dilutions (Fig. 2) should be reproduced in the well supplies (Fig. 5).

TABLE 5

Chlorine and Nitrogen Demand Data on Well Supplies

Sample	n Exponent*		k 1-hr Demand* *ppm*		Nitrogen Analyses *ppm*			Ratio of k (for Cl) to Total N
	Cl	N	Cl	N	NH_3	Albuminoid	Total	
Oakland County, Mich.								
Avon Road	0.01	0.03	3.20	0.26	0.26	0.03	0.35	9:1
Rochester Road	0.02	0.03	5.14	0.35	0.32	0.05	0.46	11:1
Princeton Road	0.06	0.05	1.17	0.06	0.04	0.04	0.18	7:1
Ypsilanti Twp., Mich.	0.07	0.07	5.86	0.34	0.22	0.21	0.62	9:1
Pontiac, Mich.	0.06	0.06	2.88	0.21	0.15	0.11	0.32	9:1
Delhi Park, Mich.	0.05	0.06	3.55	0.27	0.19	0.11	0.40	9:1
Ypsilanti, Mich.	0.09	0.09	3.04	0.21	0.13	0.12	0.35	9:1
Birmingham, Mich.	0.05	0.06	2.73	0.20	0.12	0.08	0.28	10:1
Ann Arbor, Mich.	0.05	0.04	2.00	0.08	0.06	0.05	0.17	12:1

* Value for equation $D = kt^n$.

Comparison of Surface and Ground Supplies

Proteins are characterized by a relatively high nitrogen composition; the peptide linkages limit the number of amino groups available for reaction with chlorine. Accordingly, the ratio of free available chlorine consumed at

the end of the first hour to the total nitrogen initially present is comparatively small. In contrast, the same ratio of free available chlorine consumed to the total nitrogen is measurably greater for ammonium ion and most amino acids (Table 3). In terms of extremes, the ratio for proteins approaches a minimum whereas the ratio for ammonium ion and the amino acids generally approaches a maximum.

The pattern shown by the various nitrogen compounds listed in Table 3 is interesting. The highest ratios are provided by compounds possessing chlorine-consuming groups in addition to nitrogen. Some organically bound sulfur and aromatic linkages increase the chlorine requirements, which is reflected in the falsely high chlorine demand–nitrogen ratios. The chlorine-consuming sulfhydryl group in glutathione is an example. In the absence of this group, the chlorine demand–nitrogen ratio for glutathione would approach the minimum characteristic of proteinaceous materials.

As a class, protein types exhibit the lowest ratios. Three exceptions to this rule must be noted—creatinine, creatine hydrate, and histidine—each of which also falls within the lower end of the scale. It is unlikely, however, that these compounds abound in natural supplies and sewage in concentrations which influence adversely the normal nitrogen balance and thus lead to false conclusions on whether proteins or these three exceptional compounds are present.

The chlorine demand–nitrogen ratios of Detroit raw water averaged 4 to 1 over a period of several years, rising above this figure in the presence of sanitary pollution when ammonium ions and other simple amino forms entered the supply. This comparatively low ratio lent additional support to the idea that the chlorine-consuming agents of Detroit raw water might be of a proteinaceous nature.

The well supplies and the sewage dilutions, on the other hand, exhibited higher ratios. The ratio of the averages of the chlorine and nitrogen values given in Tables 4 and 5 is approximately 9 to 1, respectively, for both the well supplies and the various sewage concentrations.

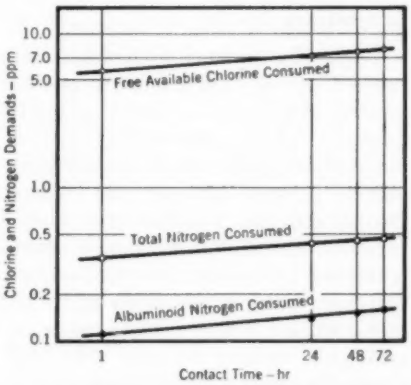


Fig. 5. Chlorine and Nitrogen Demands of Ypsilanti Township Well Water

The albuminoid nitrogen consumed in ppm = 0.11 (time in hours)$^{0.08}$. The total nitrogen consumed in ppm = 0.34 (time in hours)$^{0.07}$. The free available chlorine consumed in ppm = 5.86 (time in hours)$^{0.07}$. The chlorine dose was 8.5 ppm, and the initial ammonium nitrogen 0.22 ppm, albuminoid nitrogen 0.21 ppm, and total nitrogen 0.62 ppm.

An interesting comparison between the Detroit surface supply and the ground waters of the greater Detroit metropolitan area is afforded. The average Detroit water shows slight albuminoid and total nitrogen declines following chlorination. The well supplies, on the other hand, generally show measurable albuminoid and total nitrogen losses. Although the ammonium

ion portion of the total nitrogen accounts for much of the decrease, a notable reduction is also contributed by the organic matter present in these supplies. This finding suggests that the organic nitrogen of these particular ground waters is bound up in relatively simpler molecular forms than are those found in the Detroit surface supply. As all of the wells were deep and drilled, these chemical differences are not surprising.

Limitations

These studies were undertaken with the realization that a limited number of analytical methods would be inadequate to resolve with finality such an obviously complex reaction as that occurring between nitrogen and chlorine during the free residual chlorination process. Before this reaction is clearly understood, a considerable fund of facts will have to be accumulated and fitted into a unified whole. The present experiments support the view that additional specific and sensitive microanalyses will have to be developed and applied to the task. The problem is prodigious because of the multiplicity and complexity of the organic materials in nature. No easy and all-embracing explanation of the influence of the nitrogen factor in the chlorine demand of natural supplies is possible at this time.

Indeed, any investigation of chlorine demand will remain incomplete until suitable analytical procedures are devised for certain organically bound sulfur groups which are capable of substantial chlorine absorption (*4*). Although the nitrogen factor constituted the predominant influence in all of the natural supplies and sewage dilutions studied, the sulfur factor should not be overlooked in any overall appraisal of chlorine demand.

Summary

From a practical standpoint, these studies point out the important chlorine-consuming capacity of nitrogen groups found in ground and surface supplies. The presence of these nitrogen groups markedly affects the free-chlorine demand at the plant and subsequently in the distribution system. Under optimum conditions, the time interval during which a residual can be maintained in the mains will depend to a great extent upon the nitrogen composition of the water.

The response to chlorination differs among nitrogen groups. The nitrogen factor can conveniently be cataloged into three main categories—ammonium ion, amino acids, and proteins—each of which may be present in natural supplies in varying proportions. The so-called stability of chlorine residuals is a relative matter. The closest approach to a "stable" residual results upon the chlorination of the comparatively simple ammonium ion, unaccompanied by additional nitrogen pollution. The least stable residuals are produced in the presence of proteinaceous materials, which slowly but definitely reduce the chlorine residual with time. The presence of simpler organic nitrogen may also impose a continuing drain on any available chlorine residual.

Of course, other factors in the individual distribution system may accelerate the loss of chlorine residual. Excluding these other factors, however, a definite chlorine decline must be anticipated, even when free residual chlorination is practiced.

The chlorine and nitrogen losses attendant upon chlorination follow a pattern which may be expressed by a general mathematical equation, the constants of which provide clues to the nature of the nitrogen pollution respon-

sible for the chlorine and nitrogen demands. Similarities in the chlorine and nitrogen demands of some ground waters and some polluted surface supplies are noticeable.

Following chlorination, some simple amino compounds yield a nitrogen fraction when distilled from a medium buffered at a pH of 7.4. This fraction, which has been isolated from chlorinated sewage dilutions as well as from simple amino acids, often gives a bright off-color yellow with Nessler's reagent.

The albuminoid nitrogen content of many simple amino compounds is rapidly reduced as a result of chlorination. The loss of albuminoid nitrogen from proteinaceous matter is slight. The albuminoid nitrogen consumption in chlorinated sewage dilutions and in some polluted surface and well supplies is often an exponential function of contact time.

The total nitrogen consumed upon chlorination follows a well-defined general pattern. Ammonium ion is lost within the first hour. The simple and unsubstituted amino nitrogen of many common amino acids is consumed more slowly and over an extended period of time. Protein nitrogen shows negligible loss even after prolonged chlorination periods. The total nitrogen consumption of many amino acids, sewage dilutions, and natural waters is an exponential function of contact time. Parallel logarithmic plots of chlorine and nitrogen demand against contact time, obtained using sewage dilutions, are characteristic of the presence of a proportionately high ammonium concentration. Nonparallel lines occur when organic nitrogen is dominant. The high ammonium concentrations, together with the simple organic nitrogen forms, in the ground waters of the Greater Detroit metropolitan area result in parallel chlorine and nitrogen demands. Normally, a nonparallel effect is exhibited by Detroit raw water, a surface supply characterized by a proteinaceous nitrogen content.

Acknowledgment

This fundamental study was prompted and encouraged by the following executives of the Detroit Dept. of Water Supply: L. G. Lenhardt, Gen. Mgr.; L. V. Garrity, Asst. Gen. Mgr.; W. M. Wallace, Supt. of Filtration and Sewage Treatment; and Douglas Feben, Asst. Supt. of Filtration. The author acknowledges a deep debt to Simeon Bogush, Herbert D. Cisco, Sidney Feldsteen, Michael Garnell, John J. Gazvoda, Allen M. Hill, James Hornung, Frank B. McInerney, Thomas Myers, and William J. Redman, all sanitary chemists of the department, for performing many of the chemical analyses reported in this paper.

References

1. Calvert, C. K. Treatment With Copper Sulfate, Chlorine, and Ammonia. *Jour. AWWA*, **32**:1155 (July 1940).
2. Palin, A. T. A Study of the Chloro Derivatives of Ammonia and Related Compounds. *J. Inst. Wtr. Engrs.*, **4**: 151, 189, 248 (1950).
3. Feben, D. & Taras, M. J. Chlorine Demand Constants of Detroit's Water Supply. *Jour. AWWA*, **42**:453 (May 1950).
4. Taras, M. J. Preliminary Studies on the Chlorine Demand of Specific Chemical Compounds. *Jour. AWWA*, **42**:462 (May 1950).
5. *Standard Methods for the Examination of Water and Sewage.* Am. Public Health Assn. & Am. Water Works Assn., New York (9th ed., 1946). pp. 64-69.
6. Feben, D. & Taras, M. J. Studies on Chlorine Demand Constants. *Jour. AWWA*, **43**:922 (Nov. 1951).
7. Rudolfs, W. *Principles of Sewage Treatment.* National Lime Assn., Washington, D.C. (2nd ed., 1942). p. 19.

Educational Program of Michigan Section

By Douglas Feben

A paper presented on Sept. 24, 1952, at the Michigan Section Meeting, Battle Creek, Mich., by Douglas Feben, Asst. Supt. of Filtration, Dept. of Water Supply, Detroit.

THE provision of educational facilities for water works personnel in Michigan dates back to 1934. In the ten-year period before that date, a dozen filtration plants had been placed in operation in the counties of St. Clair, Macomb, Oakland, Wayne, and Monroe, or roughly, the area bordering that part of the Great Lakes system comprising the St. Clair River, Lake St. Clair, the Detroit River, and part of Lake Erie. In addition to these filtration plants, six others were either projected or under actual construction. The majority of the operators in these new plants had had little, if any, academic training in bacteriology. A self-appointed committee arranged for a lecture course on this subject to be given in Detroit with W. L. Mallmann of Michigan State College as the instructor. The course met with unqualified success.

Following the bacteriology lectures, Michigan State College offered water works short schools which gave students an opportunity actually to perform laboratory work in addition to receiving lectures. In 1941, James Galloway, then at Marysville, Mich., gave a course of instruction in water bacteriology, mathematics, and chlorination to twelve men in the St. Clair area, and for a few years Wayne University offered a lecture and laboratory course in water and sewage chemistry with W. M. Wallace of Detroit as the instructor.

In 1941, Michigan enacted a law calling for the certification of water treatment plant operators. As a result of having been approved under former regulations, 159 men were immediately certified. In 1942, the first examination resulted in eight out of thirteen candidates being passed. It was obvious that the men who passed were qualified and needed little, if any, preparation for such an examination. At the next examination, in 1944, only eight out of 26 candidates were successful. This record emphasized the need for an organized educational program, inasmuch as, in addition to the small percentage of successful candidates, a number of applicants were not permitted to sit for the examination because they lacked the minimum educational credits required by the regulations. Consequently a committee was appointed at the 1944 meeting of the Michigan Conference on Water Purification and was charged with the responsibility of developing such educational facilities as might be needed. To simplify the operations of this committee and to facilitate meeting as often as necessary, members within reasonable traveling distance of each other have usually been selected.

In effect, the committee has never been discharged. In February 1946, the committee became a joint committee representing both the Michigan Conference on Water Purification and

the Michigan Section, AWWA. In September 1946, the Michigan Conference on Water Purification was dissolved, and since that time the committee's activities have been sponsored entirely by the Michigan Section. The committee occasionally receives a transfusion of new blood through replacement of one or more members. Such replacements are staggered, however, to insure that some men with at least one year of experience on this committee are included on its roster.

Extension Courses

At the first meeting of the committee it was decided to query officials of Wayne University, the University of Michigan, Michigan State College, and the Michigan College of Mining and Technology to ascertain if these institutions would be interested in serving the water works profession. Surprisingly enough, all of them welcomed the opportunity but hastened to add that they had no experience in offering such courses to a separate industry or profession. It was the consensus that extension courses were the best means for instruction in technical subjects.

The extension courses as developed included:

1. *Water supply engineering—quantity and quality requirements.* The principles of design of works for the collection, purification, and distribution of water for municipal use.

2. *Fresh-water biology.* An introduction to fresh-water biology designed for persons without previous knowledge of the techniques of sampling and microscopic examination; includes a study of the algae and higher forms of life in water; also aquatic ecology of lakes and streams with stress on physical, chemical, and biological factors.

3. *Hydraulics.* Course to cover fundamentals; flow and measurement of water, particularly in pipes; hydraulics related to pumping installations and distribution systems; plumbing hydraulics.

4. *Water chemistry.* Includes concepts of valence, chemical equilibrium, solubility product and ionization constants, chemical calculations, pH, physicochemical methods in water analysis, use of indicators, organic chemistry in water purification, and general emphasis on the chemistry of the laboratory procedures used in water analysis.

5. *General and water bacteriology.* Course to cover basic bacteriology with emphasis on water bacteriology.

It was agreed that prerequisites would not be required of students, nor would college credits be earned. The board of examiners for certification of water treatment plant operators, however, agreed to assign limited credits for completed courses to help candidates become qualified in the educational category of their applications.

In presenting these courses, the committee is required to decide on a number of fundamental questions—for example, in what cities should courses be held? What is the most desirable course for any given city? On what night and at what hour should classes meet? It was found that the best way to handle these local problems was to appoint a local key man. Form letters over his signature are then prepared and he is supplied with a mailing list. He then ascertains, by mail, the expected registration for any course and the most desirable time for classes. He also makes the local arrangements for classrooms and attends to other local details. The help of these key men has been invaluable in the successful presentation of the courses.

The tuition fees were originally set at $5.00 per course, but inflation has raised them to $10.00. These low fees are made possible through the cooperation of the Michigan State Board of Control for Vocational Education.

In recent years the course on water chemistry has been extended to two years, with the first twelve-week period devoted to fundamentals and elementary work, and advanced work being offered the second year. There is also a possibility of adding a third year for actual laboratory work. On two occasions courses on stream sanitation and industrial wastes have also been offered. The following statistics cover the eight years during which this committee has been functioning:

Total number of cities in which courses have been given	10
Total number of courses	29
Average registration per course	31
Total number of registrations (approximate)	900
Total number of student-hours of instruction (approximate)	24,700

In-Service Training Courses

During the committee's initial activities, it became evident that it would be possible to hold, on a postgraduate level, an in-service training course for water works personnel. It developed that the School of Public Health of the University of Michigan was prepared to sponsor in-service courses on subjects related to public health. The school was interested in developing discussions of recent advances and current problems by acknowledged authorities on the subject, and in disseminating the information to the water works profession.

In developing such a course, the committee follows a definite procedure. First, the general subject matter of a course is decided upon and broken down into a series of papers or lectures. The material is then divided among the committee members, who prepare proposed lecture outlines. These outlines are then exchanged and circulated among the committee members so that, at the next meeting, they are able to discuss any necessary changes. When the committee is satisfied with the initial preparations, it meets with officials of the School of Public Health to request their sponsorship of such a course, which, if approved, is discussed at some length in order to make further modifications or changes and to develop a list of qualified lecturers. At this point, the school takes over, handling all the necessary correspondence, invitations to lecturers, and publicity. The lecturers are required to submit their lectures to the school in advance. School officials then meet with the committee to go over the material and to make such suggestions as may be in order. As of September 1952 four such in-service courses had been held. A summary follows:

1945—Three-Day Course

1. Review of fundamental factors in chemical equilibrium reactions and oxidation-reduction potentials—H. H. Willard
2. Chemistry of the measurement of chlorine residuals—H. A. Faber
3. Chemical explanation of free residual chlorination—N. S. Chamberlin
4. Generation and reactions of chlorine dioxide—G. P. Vincent, J. D. MacMahon, and J. F. Synan
5. Application of chlorine dioxide to public water supplies—R. D. Bates
6. Chemistry of iron in water—A. M. Buswell
7. Transformations of iron by bacteria in water—R. L. Starkey

8. Applications of chemistry and microbiology of iron in water to iron removal processes—A. H. Wieters
9. Waterborne fluorides and dental health—H. Trendley Dean
10. Nondental physiological effects of fluoride domestic waters—F. J. McClure
11. Epidemiological aspects of oral lactobacillus counts in fluoride and nonfluoride areas—P. Jay
12. Experience in the application of fluoride to a public water supply—W. L. Harris

1947—Two-Day Course

1. Chemistry of organic compounds responsible for tastes and odors—G. A. Rohlich and W. B. Sarles
2. Chemical composition of algae and its relationship to taste and odor—G. A. Rohlich and W. B. Sarles
3. Tastes and odors in water resulting from industrial wastes—C. C. Ruchhoft
4. Bactericidal properties of chloramines and free chlorine in water—C. T. Butterfield
5. Epidemiological aspects of poliomyelitis—A. G. Gilliam
6. Effect of water purification on poliomyelitis virus—G. M. Ridenour
7. Results of free residual chlorination of public water supplies in Michigan—R. J. Faust

1951—Two-Day Course

1. Toxicology as applied to public water supplies—C. W. Muehlberger
2. Qualitative and quantitative determination of toxic materials in water supplies—C. C. Ruchhoft, W. A. Moore, and F. M. Middleton
3. Sodium and its relation to hypertension—J. M. Bryant
4. Water and its relationship to the sodium intake of man—O. E. McGuire
5. Nitrates in water and their relationship to methemoglobinemia—F. H. Waring
6. Determination of nitrates in water—M. J. Taras
7. Plating wastes as toxic contaminants in ground and surface waters—L. F. Oeming
8. Summary of developments in fluoridation—H. A. Faber
9. Toxic plankton—T. A. Olson
10. The radioactivity problem in water supplies—O. R. Placak

1952—Two-Day Course

1. Principles of spectrochemistry—C. H. Humes
2. Electrical circuits and photocells for instruments—H. S. Bull
3. Demonstration of colorimeters
4. Nephelometry—C. H. Humes
5. Fluorimetry—W. G. Sink
6. Demonstrations of nephelometers and fluorimeters
7. Polarography—C. L. Rulfs
8. Electrometric titrations—W. G. Sink
9. Demonstrations of electrometric titrations and polarography
10. Theory of pH—A. L. Ferguson
11. Electrometric determination of pH —W. N. Greer
12. Demonstrations of electrometric and colorimetric pH instruments

A summary of the statistics on these courses follows:

Total number of courses to date	4
Average registration per course	95
Total number of registrations	380
Total number of student-hours of instruction	5,082

Institutes

The extension and in-service training courses provide educational facilities for those men in the most heavily populated areas of the state. The extension courses, because of their 10- to 12-week duration, are beyond the reach of the men in the sparsely populated areas in the Upper Peninsula and the northern part of the Lower Peninsula; moreover, the in-service training courses are on too high a level for most

of the men in these areas. Thus, the problem of reaching these men and giving them the courses they needed presented itself. The solution finally adopted was suggested by Everett J. Soop, Director, University of Michigan Extension Service. The solution was one- or two-day institutes to be held at strategic points. This method retains the advantages of an extension course in that an instructor presents the subject matter, but the amount of travel by both student and instructor is materially reduced.

The subject matter covered in these institutes has been confined to main disinfection, water sampling and bacteriology, construction and operation of wells, chlorination, legal aspects, records, fluoridation, certification, and color removal. The committee feels that an extension of the institute system is its current problem. Present plans call for a division of the state into five or more regions in each of which could be held a one-day institute of instruction. To date, seven such institutes have been held in two cities, the statistics for which follow:

Average registration	61
Total number of registrations	428
Total number of student-hours of instruction	4,650

Refresher Courses

For the past three years, one-day refresher courses have been given for men in those treatment plants which do not require clarification by chemical precipitation. These courses are held before the certification examinations are given and, on recommendation by the committee, are conducted by staff members of the state health department. To date, three such courses have had a total registration of 58, representing a total of 444 student-hours of instruction.

Summary

A combined summary of these activities reveals that in the eight years during which this committee has been functioning, there has been a total registration of 1,766, representing a total of more than 34,800 student-hours of instruction. It is difficult to evaluate quantitatively the benefits derived from this program. The in-service training courses have enabled operators to keep abreast of recent developments. All the courses have made it possible for many operators to meet the educational qualifications required by certification regulations. Finally, when an operator is permitted to sit for a written examination, he has a better chance of making a passing grade. Since 1942 written examinations have been given to 442 candidates for certification. As a result of these examinations, 238 certificates have been issued, representing 54 per cent successful candidates. This percentage is a distinct improvement over the 30 per cent successful candidates in 1944 and 1945. The education committee feels that its activities have contributed in some measure to this improvement.

Acknowledgment

The membership of this committee has never exceeded four. During the eight years of its existence, the following men, in addition to the author, have given service to the committee: J. A. Borchardt, J. E. Cooper, A. T. Dempster, R. J. Faust, H. E. McEntee, Walter Muhlitner, and J. E. Vogt.

Short Courses and Correspondence Courses for Water Plant Operators

By H. K. Gidley

A paper presented on Sept. 17, 1952, at the Kentucky-Tennessee Section Meeting, Knoxville, Tenn., by H. K. Gidley, Director, Div. of San. Eng., West Virginia Dept. of Health, Charleston, W.Va.

PUBLIC health authorities encourage the development of water supplies from sources which are reasonably safe before treatment inasmuch as no treatment process can be considered foolproof. Unfortunately the abuse of surface streams is so general that in many sections of this country water with a high degree of natural purity is no longer available. Consequently, polluted sources must frequently be used.

When the potability of a water supply depends upon treatment, its continuing safety rests in the hands of an individual—the plant operator. Although treatment plants and processes are designed to be as foolproof as they can reasonably be made, the guiding hand of the operator is needed. A momentary lapse or miscue due to the ignorance of the operator could be disastrous to the community.

Generally, the larger water treatment plants are better designed, better equipped, and better operated than the smaller plants. The small plant is likely to have the same treatment problem and be more difficult to operate than the large plant, yet frequently the small water utility cannot or will not pay the salary a competent and experienced operator justly demands. The operating personnel problem in small plants is often met, unfortunately, by the employment of a man who has had little or no experience in water treatment.

One of the major activities of a state health department engineering division is public water supply control. Such control generally covers approval of source, review and approval of plans, inspection of plant operation, review of operation reports, and some degree of bacteriological control. Some states have legal authority to examine and license water plant personnel.

Health departments are confronted with the continuing problem of incompetent operators because so many of the men employed in these important jobs are poorly educated and lack inherent capabilities. In the author's opinion, more lasting results could be achieved through maintaining a high educational standard as a condition of employment than by the use of training techniques to improve those who arrive on the job with so many undesirable limitations. Perhaps the water utilities are doing too much to train the operator after he arrives on the job, and are neglecting the approaches which would attract better qualified men.

Short Schools

The period 1910–30 was one of widespread construction of water treatment plants throughout the United States. With the increase in the number of

plants came the need for more and better trained operators. State health department engineering divisions were established in practically all of the states between 1910 and 1920, and early recognition was given to water plant operation problems.

Early in the 1920's several states began holding conferences and short schools for operators. The term "short school" is somewhat elastic, but, generally, it means an intensive course of instruction and demonstration lasting a few days. These schools are usually held at colleges and are sponsored jointly by the state health department and the college, with water works organizations sometimes participating.

In 1947, sixteen states reported that during the year, a total of 24 courses, with 2,400 operators in attendance had been held (*1*). The time spent in such training varied from 1 day (8 hours) to 25 days (200 hours). Most courses or short schools last 5 or 6 days. Michigan, Texas, Florida, Pennsylvania, Oklahoma, and North Carolina have effectively used the short school method of instructing operators.

Everts (*2*) pointed out the need for training programs and commented favorably on the short school, although he observed that such schools do not attract the operators from the small plant. He suggested frequent, local, one-day conferences instead of the central, annual, one-week short school. The local-conference idea has been used effectively by Oklahoma (*3, 4*), Texas (*5*), Indiana (*6, 7*), Oregon (*2*), and other states.

The value of the short school, if properly organized and conducted, has been established beyond question, but it should not be considered the final answer to the problem. The short school has several weaknesses. Operators of small plants quite often cannot attend because they cannot leave the job. Unenlightened city officials frequently will not pay the operators' expenses to short courses and conferences. Some operators are reluctant to attend and expose their inadequacy when compared to other operators. Short schools generally attempt to cover too much ground in the allotted time, and some of the operators do not receive much benefit from the course because of this speedup. There is a tendency to gather together a group of men having widely divergent backgrounds in education, experience, and ability, thus making it difficult to have a balanced course of instruction. These variations in background lead to a "shotgun" style of instruction and a vague hope that every man will absorb a few pellets of information.

Extension Courses

During the past few years, Michigan, Texas, and Oklahoma (*1*) have developed extension courses for the training of water plant operators. In Michigan, the courses are given at several convenient locations. The courses are presented by a college and the instructor meets with the operators at night. Night classes do not interfere with daytime work and also permit operators from nearby communities to travel to the central meeting place after work.

Although the extension course method of training is probably the best that could be devised, it is doubtful if many states will be able to make use of it. An extension course of this kind should be conducted by a college or university, and generally these institutions are not interested in presenting specialized courses with a very limited appeal.

Examination and Licensing

The examination and licensing of water plant operators is mentioned because, in those states where licensing or certification is practiced, the act of licensing stimulates and energizes the operator into improving his knowledge of water treatment. In those states where compulsory licensing is in effect, operator training is of particular interest. The licensing laws and practices in the United States have been completely surveyed recently (*8*) and it has been determined that eight states require certification and twelve have voluntary plans in effect.

Correspondence Courses

The training of operators through correspondence courses has apparently not been employed to any extent by state health departments. The author has had some experience with correspondence training of water plant operators in West Virginia, and a discussion of the techniques and materials used may be of interest, inasmuch as this experience has not been previously reported in the water works literature.

During the four-year period, 1938–42, the West Virginia Dept. of Health used a correspondence scheme to stimulate thought and study among operators in the state. Each month the department mailed out a list of five questions (a different set of questions to each of the three classes of operators licensed in West Virginia), the operator being expected to answer and return the questions during the month. In addition, the operator was requested to read and abstract a selected article from a current issue of a water works magazine or journal. This question series was very well received and aroused considerable interest. Most of the operators faithfully returned the answers for correction and grading. The department was forced to discontinue the question series during the war years because of the reduced staff of the engineering division.

In November 1950 the West Virginia Dept. of Health introduced a voluntary correspondence course to aid the less experienced operators of small filtration plants. There are many small plants — 0.025–0.25 mgd output — in West Virginia, and the course content was arranged to benefit this particular group of operators. It was felt that the correspondence technique would reach many operators who would not make use of other training aids. There is also some advantage to the operator in working with his own tools in his own plant, and in working with the water he is required to treat day after day.

The course is conducted by the state health department without cost to the student. To enroll for the course, all an operator must do is write a letter to the department. In reply, he will receive a form letter telling him how the course is conducted, and that he must have access to Cox's *Laboratory Control of Water Purification* (*9*). He must also have access to a plant in which the experiments and studies may be completed.

After enrollment, the department mails Lesson No. 1 to the individual, who completes and returns it to the department for grading. Lesson No. 1 is graded and returned with Lesson No. 2. This procedure is followed until all the lessons have been completed, whereupon the student receives a certificate of completion.

At present 50 operators are enrolled in the course and two have successfully completed it. Thus far no effort has

been made to enroll operators or to hurry them along in their studies. The department is now preparing to stimulate a considerable number who rapidly completed the first few lessons but slowed down after the novelty wore off.

The correspondence course consists of eleven lessons, each designed to give the operator practical working experience with a problem or problems common to most plants. Every lesson includes a reading assignment in *Laboratory Control of Water Purification (9)*, a list of the apparatus and materials required, a discussion, and directions for completing the lesson. Lesson No. 8, which is given in the Appendix (page 71), illustrates the makeup of a typical lesson. The subject matter covered in the course is indicated by the titles of the eleven lessons: Know Your Plant; Pumping Rates; Rating of Chemical Feed Equipment; Tests for Alkalinity and pH; Preparation of Stock Solutions for Coagulation Studies; Coagulation Studies by Use of Jar Test; Flow Characteristics of a Settling Basin; Examination of Filters; Filter Rates and Backwashing; Chlorine Tests; and Treating a Water Supply to Prevent Corrosion.

From the standpoint of an educator, the health department's efforts are undoubtedly amateurish; the self-study course could be improved by a specialist in the field. The department is convinced, however, that the approach has merit for the conditions which prevail in West Virginia.

Summary

Many of the water supplies in the United States are derived from polluted sources. There is a continuing need for capable, well-trained water and sewage plant operators. The need for well-trained operators is especially acute in the small plants and is a concern of state health departments.

For the past 30 years health departments have sought to improve water plant operation through routine field inspections, licensing and certification of operators, and the promotion and scheduling of conferences, meetings, short schools, and extension courses. All of these efforts have been productive, and the qualifications and professional standing of operating personnel have been materially improved.

One training technique which has not been used by health departments to any extent in the past is the correspondence course. Current experience in West Virginia with an elementary correspondence course for water plant operators indicates that such courses are worth while.

References

1. Ingram, William T., et al. Scope and Value of Water Works Schools. *Jour. AWWA*, **40**:1005 (Oct. 1948).
2. Everts, Curtiss M. Water Works Short Schools. *Jour. AWWA*, **40**:653 (June 1948).
3. The Oklahoma Plan for Training Plant Operators. *Jour. AWWA*, **32**: News of the Field, p. 28 (Apr. 1940).
4. Darcey, H. J. Licensing and Training Water Plant Operators in Oklahoma. *Jour. AWWA*, **37**:139 (Feb. 1945).
5. Water Works Advancement in the Southwest Through the Short Course. *Southwest Water Works Jour.*, **22**:9:11 (1940).
6. Laux, Paul. Report on Indiana District Meeting. *Jour AWWA*, **29**:1105 (Aug. 1937).
7. Richetta, J. D. Report on Indiana District Schools. *Jour. AWWA*, **33**:619 (Apr. 1941).
8. Committee Report. Licensing Laws and Practice in the United States. *Jour. AWWA*, **41**:111 (Feb. 1949).
9. Cox, Charles R. *Laboratory Control of Water Purification*. Case-Shepperd-Mann Pub. Corp., New York (1946).

APPENDIX

Sample Correspondence Lesson—Examination of Filters

1. *Object:* To teach the operator how to examine and judge the condition of a rapid sand filter.

2. *Reading Assignment:* In *Laboratory Control of Water Purification* read pages 213 to 217.

3. *Material Required:* Garden rake; measuring rule.

4. *Discussion:* A typical filter bed consists of a 24- to 36-in. depth of specially prepared sand supported by a 14- to 18-in. bed of graded gravel. The gravel should remain in an undisturbed, level bed. The sand should be level, free of cracks, mudballs, and hard spots. It is not uncommon to find filters in very poor condition. The supporting gravel is sometimes found in a disturbed condition, mixed into the sand. Sand may have been washed away by excessive washing so that only a dangerously thin layer remains. Hard spots and mudballs cut down the effective filtering area, cause short filter runs, and require excessive wash water.

5. *To Complete the Lesson Proceed as Follows:* For this lesson examine and report on one filter. For your own information you should regularly examine all of the filters in your plant.

A. Measurement of Thickness of Sand

1. Use a long-handled garden rake and lower it vertically with the rake end down until it rests on top of the sand. Use the top of the filter wall as a reference point and make a mark on the rake handle.

2. Backwash the filter and while it is washing, lower the rake gently until it comes to rest on the gravel. Using the same reference point, make another mark on the rake handle. Hold the rake vertically and "feel" the gravel at several points, especially along the walls and in the corners. If the wash water seems to break through at any particular point, check that point. Determine whether the gravel bed is level and undisturbed or has mounds and craters. *Do not rake the gravel or disturb it in making this test.*

3. Measure the distance between the two marks on the rake handle. This distance is the same as the depth of the sand in the filter.

4. Record the information asked for below:

a. Depth of filter sand (in.) .....

b. Filter gravel is level and undisturbed: yes ( ); no ( ).

B. Hard Spots in Filter

Backwash the filter and while it is washing, use the garden rake and pass it back and forth through the expanded sand. (*Do not rake or disturb the gravel.*) If the sand is clean and washing properly, the rake will easily and freely pass through the sand without resistance. Feel for hard spots which will offer some resistance to the rake. A hard spot is an area where the filter is not washing properly, and the sand has become cemented together with "mud." Sketch a plan of a filter and indicate any areas which may be classed as hard spots.

C. Measurement of Mudballs

Use the Baylis method of measuring mudballs as described on page 216 of *Laboratory Control of Water Purification.* Follow the procedure in detail. A sampling tube can be made from a tin can. Record the results below:

Number of samples examined .....
Total volume of samples (cc) .....
Total volume of mudballs (cc) .....
Per cent of mudballs .....

D. Summary of Conclusions

1. The filter sand bed is ..... in. thick which (is) (is not) adequate.

2. The gravel bed (is) (is not) level and undisturbed.

3. The filter bed (does) (does not) have hard spots.

4. The filter has ..... per cent mudballs in upper 6 in. of filter sand.

Cold-Weather Protection for Hydrants

Staff Report

The increasing difficulty experienced by the Hartford, Conn., Water Bureau in obtaining supplies of Type N denatured alcohol for use as a fire hydrant antifreeze recently initiated a search for a safe and economical substitute. That search, in turn, has brought to light some facts and practices in hydrant protection that will be of interest to all who are faced with the problem of preventing hydrant freezing.

First, from the chemical industry, it has been learned that the term, "Type N denatured alcohol," refers to the type manufactured by fermentation rather than synthetic producers. In use as an antifreeze, it is usually completely denatured alcohol to which rust and corrosion inhibitors have been added. The primary reason for the present difficulty in obtaining the antifreeze is probably the relatively high price of the ethyl alcohol compared with methanol, which is actually a more efficient freezing-point depressor. The one drawback to the use of methanol in hydrants appears to be its greater toxicity.

From other cities noted for their cold weather has come a variety of reports. Duluth, Minn., which was faced with precisely the same problem as Hartford five years ago, successfully resorted to methanol, which is readily available and approximately a third lower in cost. At Manchester, N.H., on the other hand, the use of Type N denatured alcohol continues in the absence of any supply problem. Meanwhile, the Butte, Mont., Water Co., which had experienced trouble from the freezing of ground water that rose in the hydrant barrel, reported success with the use of calcium chloride, added in amounts sufficient to make a solution safe to − 40°F.

Other cities in Montana, as well as Augusta, Me., and Ottawa, Ont., rely on physical rather than chemical methods of protection. A number of Montana towns agree with the Augusta Water Dist. in holding that "the best antifreeze is a dry hydrant." They plug the drain and keep the barrel pumped dry all during the winter season. At Augusta, inspections begin on October 15 and continue through the winter at no more than two-week intervals, and the fire department, which is the only authorized user of the hydrants, reports every use. The more severe climate at Ottawa necessitates even more careful control, particularly as the most frequent manifestation of frost action is the seizing of the hydrant stem in the packing gland as a result of condensation of moisture at that point. At Ottawa, all hydrants are inspected daily and thawed immediately if frozen, and a steam boiler is dispatched to all fires upon receipt of the alarm. In late winter, if frost has penetrated the ground sufficiently to freeze the lateral, electrical thawing followed by thorough flushing is sometimes required.

In Minnesota, where the state health department has ruled stop and waste hydrants unacceptable for use at railroad watering points, protection against freezing at some places is provided by wrapping the hydrant with electric thermotape. Such protection, of course, requires a connection to a constant source of electric power, but the heating element used is not a high consumer of current.

The Detectability of Low-Level Radioactivity in Water

By A. S. Goldin, J. S. Nader, and L. R. Setter

A contribution to the Journal by A. S. Goldin, Chemist; J. S. Nader, Physicist; and L. R. Setter, Sr. Scientist, all of the Environmental Health Center, U.S. Public Health Service, Cincinnati, Ohio.

IT is axiomatic that the ever-growing production and use of radioactive materials will lead to increasing problems of radioactive pollution of air and water with consequent potentially harmful effects. The Atomic Energy Commission, recognizing the hazards, has instituted measures of control and maintains records of pollutants. Because of the increasing availability of radioactive isotopes to industrial, medical, and research users who may have less elaborate facilities for controlling their wastes, it may be expected that radioactive-pollution problems will increase. Furthermore, the potential use of radiological weapons cannot be ignored. In order to prevent the harmful effects which might occur as a result of excessive pollution, it is necessary to devise methods of detecting and measuring low levels of radioactive pollution.

There have been a number of articles (*1–6*) on the determination of radioactivity in water. Cowan and Nehemias (*2*) have made a survey of the problems involved in low-level determinations. Their paper considers the use of scintillation counters for detection of alpha activity and end-window Geiger-Muller counters for detection of beta-gamma activity.

The Environmental Health Center has been studying the impact of radioactivity upon the environment, particularly the pollution of surface and ground water. The quantities of natural radioactivity and the minor pollution from some nuclear-energy operations have usually been so small that chemical separations, energy determinations, and half-life measurements were not feasible. It is the purpose of this paper to consider the detectability of alpha and beta radioactivity in water at and below the presently accepted tolerance level of 1×10^{-7} microcuries (μc) per milliliter—100 micromicrocuries ($\mu\mu$c) per liter (*7*).

Statistical Considerations

The lower limit of radioactivity that can be determined by observations over a finite time is fixed by the statistically random nature of radioactivity. It is well known that radioactive disintegrations occur randomly in a manner described by the Poisson distribution. As a consequence of this characteristic, the counting rate of a sample fluctuates about a mean value.

In the determination of any counting rate, there are two measurements made —the observed counting rate, R_o, of sample-plus-background, and the back-

ground counting rate, R_b. The desired net counting rate, R, of sample alone is the difference between the observed and the background counting rates:

$$R = R_o - R_b \quad \ldots\ldots (1)$$

It can be shown (*see* Appendix, p. 80) that the standard deviation, s, of the net counting rate is given by the formula:

$$s = \left(\frac{R_o}{t_o} + \frac{R_b}{t_b}\right)^{\frac{1}{2}} \quad \ldots\ldots (2)$$

where t_o and t_b refer to the time during which R_o and R_b are respectively counted.

If it is assumed that the normal distribution is a good approximation of the Poisson distribution—an assumption which is valid if a reasonably large number of radioactive disintegrations are observed—then, at the 95 per cent level of confidence, the limit of error, E, is 1.96 times the standard deviation:

$$E = 1.96\, s = 1.96 \left(\frac{R_o}{t_o} + \frac{R_b}{t_b}\right)^{\frac{1}{2}} \quad \ldots (3)$$

The minimum detectable counting rate, R_m, is taken to be equal to the limit of error of the counting rate, R—that is, it is that value for which zero is no longer included within the 95 per cent confidence limits. This means, for example, that a counting rate of 4.9 ± 5.0 is not considered detectable, whereas 5.1 ± 5.0 is considered detectable.

R_m can be substituted for E in Eq 3 to give:

$$R_m = 1.96\, s = 1.96 \left(\frac{R_o}{t_o} + \frac{R_b}{t_b}\right)^{\frac{1}{2}} \quad (4)$$

It is shown in the Appendix that the error in R_m for any given total counting time is at a minimum if $t_o = t_b = t$, when $R_o = R_b$. This condition is approximately true for the low counting rates being considered. The minimum detectable activity, R_m, is then equal to:

$$R_m = 1.96 \left(\frac{R_m + 2R_b}{t}\right)^{\frac{1}{2}} \quad \ldots (5)$$

Figure 1 is a graph of Eq 5 for $t = 32$ min. This counting time has been arbitrarily selected as the longest practical counting period for assaying a large number of samples. Figure 1 shows that the minimum detectable counting rate is approximately proportional to the square root of the background counting rate for backgrounds greater than 0.3 count per minute (cpm). Over the usual range of beta background counting rates—15–65 cpm—the minimum detectable counting rate ranges from 2 to 4 cpm. Over the usual range of alpha background counting rates—0.1–1.0 cpm— the minimum detectable counting rate ranges from 0.22 to 0.55 cpm.

Figure 1 includes background rates less than 0.3 cpm or 10 counts per period. Although the statistics are not completely reliable in this low range, the extension of the graph of Eq 5 is a fair estimate and shows a diminishing return of minimum detectability by a further reduction in the background counting rate (*2*). In other words, a substantial lowering of the background counting rate in this range does not give a proportional improvement in the minimum detectable rate.

It should be emphasized that Eq 5 is calculated on the basis of purely random fluctuations. If a systematic variation exists, such as one due to atmospheric conditions or to loading of the electrical circuits, the calculated minimum detectable counting rates are not valid. Such systematic variations are detected by determining the background several times during the day.

Counter Efficiency

The foregoing minimum detectable counting rates apply only to the number of counts detected by the instrument; they do not refer directly to the sample disintegration rate or to the activity of the sampled material. In order to minimize the effect of the counting error on the minimum detectable activity, it is desirable to test as large a sample as practical and to detect as large a fraction of its disintegrations as possible.

The major factors which determine the overall efficiency of detection include: [1] geometry; [2] window and air absorption; [3] back-scatter; [4] self-absorption; and [5] self-scatter. Self-absorption and self-scatter are primarily determined by the nature of the sample, and are only secondarily affected by the detector. For the highest detection efficiency, it is desirable that the geometry and back-scatter factors be large, with a minimum of window absorption and self-absorption.

End-window Geiger-Muller counters are widely used for the determination of beta radioactivity. They are particularly suitable for counting the relative concentration of a single isotope having a moderate-to-high maximum energy, such as in tracer studies. The counting efficiency of end-window tubes, however, is usually less than 20 per cent for samples spread on even a small area, because of the low geometry and the absorption of radiation by the window and air. The extent of window absorption losses is dependent on the energy of radiation, being much greater for low-energy emitters.

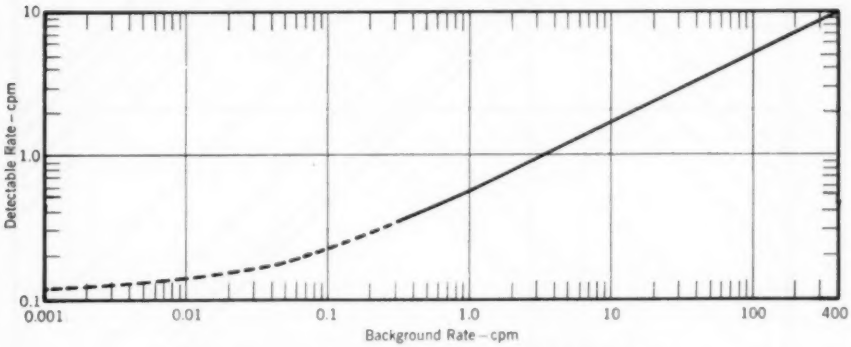


Fig. 1. The Minimum Detectable Counting Rate

The background levels are variable. The sample and background were counted for 32 min each.

Internal sample counters and scintillation counters can have a geometry as high as 50 per cent, and, furthermore, have no losses from window and air absorption. They are also able to detect all the back-scattered radiation, which amounts to approximately 25 per cent of the total radiation from a beta emitter mounted on a backing having a medium atomic number, such as copper. Although internal sample counters are available in both proportional and Geiger types, the proportional counter has the advantage of

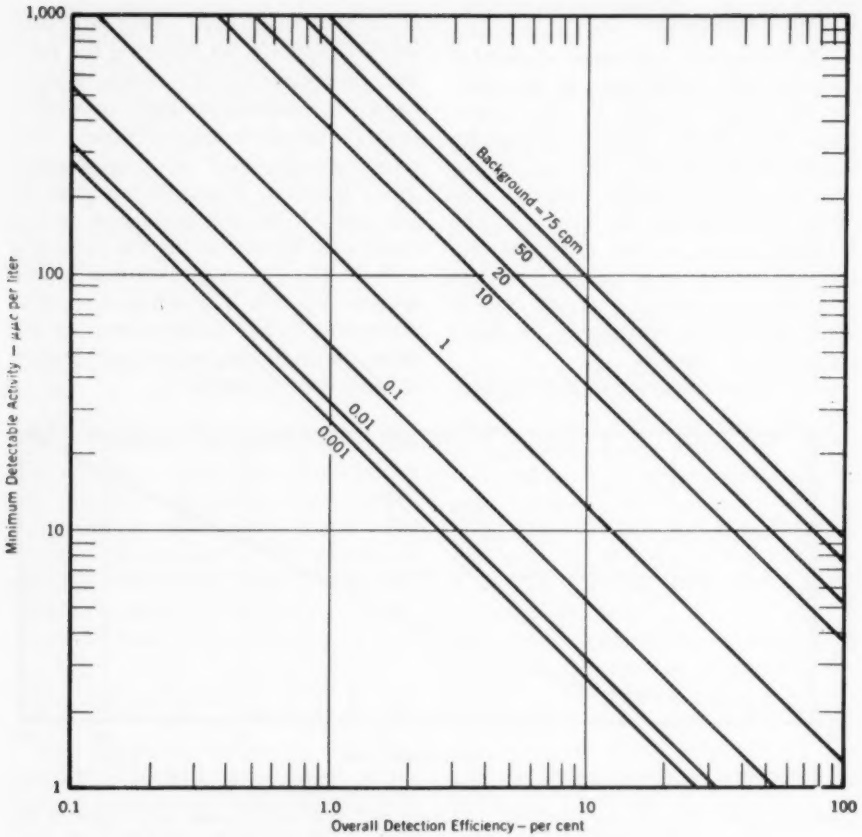


Fig. 2. The Minimum Detectable Radioactivity of 200-ml Samples

The 200-ml samples of water were evaporated and counted for 32 min in instruments having various efficiencies and background levels. The following are typical efficiencies: internal proportional counter—60–75 per cent for beta activity and 51 per cent for alpha activity; end-window Geiger-Muller—1–15 per cent for beta activity; scintillation counter—15 per cent for alpha activity (2).

being able to determine alpha radiation in the presence of beta. When self-absorption is negligible, the overall counting efficiency of an internal proportional counter was found to be 51 per cent for alpha emitters, and 73 per cent for a beta emitter. These values were checked by counting the alpha particles from a radium D + E + F calibrated source and beta particles from a P^{32} calibrated solution, both of which were obtained from the National Bureau of Standards.

Sample Preparation

The ideal sample would be one representing a large portion of the original

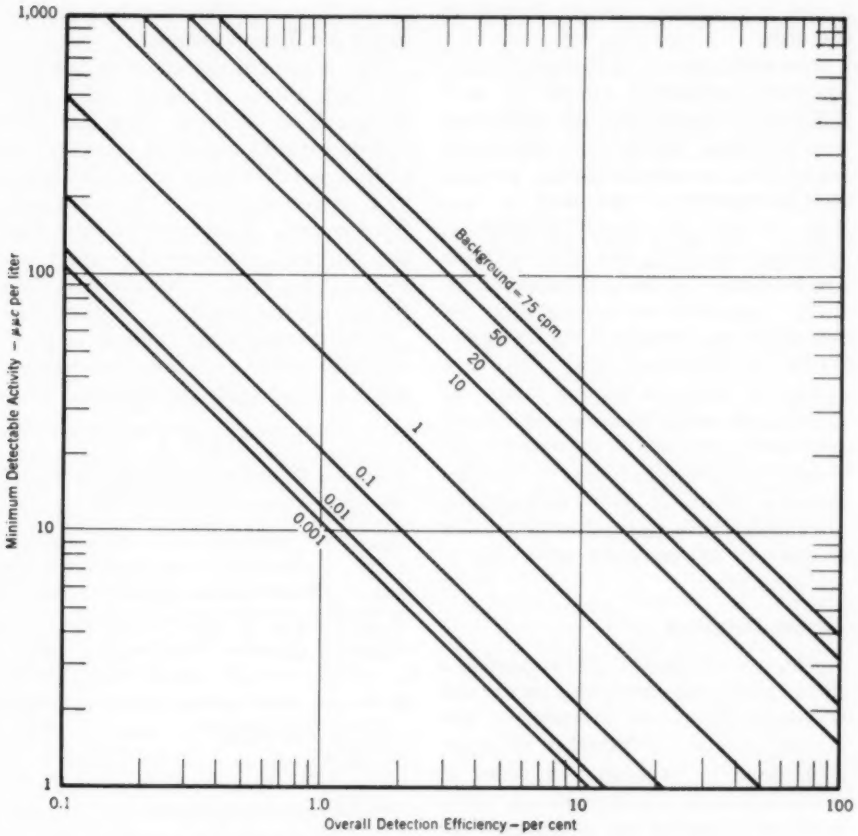


Fig. 3. The Minimum Detectable Radioactivity of 500-ml Samples

The 500-ml samples of water were evaporated and counted for 32 min in instruments having various efficiencies and background levels.

material deposited as an infinitely thin film over a small area. In practice, a compromise among these mutually contradictory requirements must be made. In order to get a large sample into a counting dish and still keep the sample thin, it is necessary to use a dish of large area. This is possible only if the counter is efficient in detecting radiation over the extended area. The efficiency of end-window Geiger-Muller counters in detecting radiation decreases as the source area becomes larger (*8*), whereas larger samples can be used in some scintillation and internal counting chambers with very little loss of efficiency. Aluminum milk bottle caps 4.8 cm in diameter with a useful area of 20 sq cm have been adopted for use in internal gas-flow counting chambers. Tests have shown a loss of less than 2 per cent in the detection of radiation from a source extended over 20 sq cm as compared to an equivalent source

1 mm in diameter centrally located in the dish.

The evaluation of self-absorption in low-level radioactive samples is very difficult. Significant self-absorption losses of beta radioactivity have been found (*9*) in mixed fission product samples having a thickness of less than 2 mg per square centimeter, whereas Graf (*10*) has reported even greater losses for the soft-beta emitter, Ca^{45}. Inasmuch as a correction for self-absorption is impossible for radioactivity of unknown energy, the procedure of using as large a sample as practical in order to obtain maximum sensitivity, even at the expense of precision, has been adopted. Samples showing relatively high radioactivity are subsequently retested using smaller samples to minimize the error due to self-absorption.

Levels Detected

The overall detectability depends on the factors given above and on the size of sample taken. In the authors' laboratory, samples of 200 ml or more are evaporated to dryness. In order to avoid losses by adsorption on glassware, the samples are evaporated directly in the counting dishes at a temperature of 70–80°C. Although the procedure is time consuming, it avoids spattering and permits the deposition of a uniform film of sample solids. The radioactivity of suspended solids is determined by filtering a sample, usually 500 ml, through a molecular filter (*11*). The membrane and suspended solids are then dried and counted.

The minimum detectable level of radioactivity in 200-ml samples of water is plotted against the overall detection efficiency in Fig. 2. A family of curves is given for various backgrounds up to 75 cpm. Figure 3 is a similar graph for 500-ml samples.

The minimum detectable radioactivity levels shown in Fig. 2 and 3 were recapitulated in Table 1 for 200- and 500-ml samples and were compared to Cowan and Nehemias' detectable limits (*2*) converted to the 95 per cent confidence level. The table indicates that the internal proportional counter detects a lower level of alpha activity than the scintillation counter. Similarly, the internal proportional counter is more sensitive to beta radiation than the end-window Geiger-Muller counter. Furthermore, the sensitivity of the internal proportional counter does not differ appreciably for beta radiations of different energies.

TABLE 1

*Minimum Detectable Radioactivity of Water**

Sample Size *ml*	Alpha Activity *μμc per liter*		Beta Activity *μμc per liter*	
	EHC**	Cowan (*2*)	EHC**	Cowan (*2*)
200	1.5†	3.6‡	11§	
500	0.6†		5§	19‖
				60#

* Negligible self-absorption.
† For an alpha emitter.
‡ For Po^{210}.
§ For a beta emitter.
‖ For P^{32}.
For C^{14}.
** Environmental Health Center.

A procedure (*12*) for the determination of alpha and beta radioactivity in surface and ground water and in fresh water biota has been adopted by the Environmental Health Center and embodies the principles and techniques set forth in this paper.

Summary

A study of the factors involved in the detection of low-level radioactivity

in water has been made. These factors include: [1] the background counting rate; [2] the efficiency of radiation detection; and [3] the sample size. The greatest sensitivity is obtained by counting large dried samples in efficient counting equipment. A low background, although desirable, is less important than efficient detection and large sample size. Internal sample proportional counters have been shown to be more sensitive than end-window Geiger-Muller counters for this application.

A formula has been derived which relates the minimum detectable counting rate to the background counting rate. Graphs are presented which relate the minimum detectable radioactivity levels of water to background, counter efficiency, and sample size.

When the dry solids of 200-ml samples are counted for 32 min in an internal proportional counter, the statistical lower limits of detectability of alpha and beta radioactivity are shown to be 1.5 and 11 $\mu\mu$c per liter (1.5×10^{-9} and 1.1×10^{-8} μc per milliliter) respectively, as compared to the general maximum permissible level in drinking water of 100 $\mu\mu$c per liter (1×10^{-7} μc per milliliter).

References

1. Task Group Report. Instrumentation and Methods for Testing Radioactive Contamination in Water. *Jour. AWWA*, **44**:583 (July 1952).
2. Cowan, F. P., & Nehemias, J. V. Sensitivity of the Evaporation Method of Liquid-Waste Monitoring. *Nucleonics*, **7**:5:39 (1950).
3. Duncan, J. F., et al. Estimation of Radioactive Strontium, Barium, Cobalt, and Iodine in River Water. *Jour. Soc. Chem. Ind.*, **69**:25 (1950).
4. Emmons, A. H., & Lauderdale, R. A. A Method for Estimating Low Levels of Radioactive Contaminants in Water. *Nucleonics*, **10**:6:22 (1952).
5. Fields, P. R., & Pyle, G. L. Detection of Trace Quantities of Radioactive Materials in Waste Streams. *Anal. Chem.*, **23**:1004 (1951).
6. Hursh, J. B.; Zizzo, S.; & Dahl, A. H. Survey Meters for Water Monitoring. *Nucleonics*, **9**:5:C–16 (1951).
7. Morgan, K. Z. Lecture at In-Service Training Course in Radiological Health, University of Michigan School of Public Health. Univ. of Michigan, Ann Arbor, Mich. (1951). p. 73.
8. Cook, G. B.; Duncan, J. F.; & Hewitt, M. A. Geometrical Efficiency of End-Window Counters. *Nucleonics*, **8**:1:24 (1951).
9. Nader, J. S.; Hagee, G. R.; & Setter, L. R. Radioactive Measurements II, Self-Absorption. Unpublished data.
10. Graf, W. L.; Comar, C. L.; & Whitney, I. B. Relative Sensitivities of Windowless and End-Window Counters. *Nucleonics*, **9**:4:22 (1951).
11. Clark, H. F., et al. The Membrane Filter in Sanitary Bacteriology. *Public Health Repts.*, **66**:951 (1951).
12. Nader, J. S.; Setter, L. R.; & Goldin, A. S. The Determination of Alpha and Beta Radioactivity in Surface and Ground Water and in Fresh Water Biota. Activity Report, Environmental Health Center, U. S. Public Health Service, No. 12, p. 5 (Apr.–June 1952).
13. Weatherburn, C. E. *A First Course in Mathematical Statistics*. Cambridge University Press, Cambridge (1946). pp. 47–49.

APPENDIX

Radioactivity Statistics

The radioactivity statistics which follow include equations for determining the standard deviation of net rate and the most efficient counting time.

Standard Deviation of Net Rate

The Poisson distribution formula gives the probability of exactly k events occurring when the average or expected number of events is m:

$$P(k) = \frac{e^{-m}m^k}{k!} \quad \ldots\ldots\ldots (6)$$

It is shown in texts on mathematical statistics (*13*), that a Poisson distribution with mean m is characterized by having its variance also equal to m. Radioactive disintegrations occur randomly in a manner described by the Poisson formula.

The quantity which is of the greatest interest in radioactivity determinations is usually the rate of the events, not their number. These rates do not fluctuate in a Poisson manner, but the standard deviation of the rate can readily be determined.

Suppose n events are observed in time t. Then the rate r is given by $\frac{n}{t}$. As r is a function of n, its variance can be found by the formula:

$$V_r = \left(\frac{dr}{dn}\right)^2 V_n = \frac{1}{t^2} V_n \quad \ldots\ldots (7)$$

As $V_n = n$, Eq 7 becomes:

$$V_r = \frac{1}{t^2} n = \frac{n}{t^2} = \frac{r}{t} \quad \ldots\ldots (8)$$

Applying Eq 8 to the rates R_o and R_b gives the variances, V_o and V_b, of these rates:

$$V_o = \frac{R_o}{t_o} \quad \text{and} \quad V_b = \frac{R_b}{t_b} \quad \ldots (9)$$

As the net counting rate, R, is the difference between these two rates, its variance, V, is equal to the sum of their variances:

$$V = V_o + V_b = \frac{R_o}{t_o} + \frac{R_b}{t_b} \quad \ldots (10)$$

The standard deviation, s, is the square root of the variance, or

$$s = V^{\frac{1}{2}} = \left(\frac{R_o}{t_o} + \frac{R_b}{t_b}\right)^{\frac{1}{2}} \quad \ldots (11)$$

as stated in Eq 2.

Most Efficient Counting Time

It is desired to establish the optimum counting times, t_o and t_b, to minimize the error in R, subject to the condition that the total counting time, T, be constant:

$$T = t_o + t_b = \text{constant} \quad (12)$$

Then

$$dT = dt_o + dt_b = 0 \quad \ldots (13)$$

or

$$dt_o = -dt_b \quad \ldots\ldots (14)$$

To minimize the error, it is sufficient to minimize the variance by setting its derivative with respect to either t_o or t_b equal to zero:

$$dV = -\frac{R_o\,dt_o}{t_o^2} - \frac{R_b\,dt_b}{t_b^2} \quad \ldots (15)$$

$$dV = \frac{R_o\,dt_b}{t_o^2} - \frac{R_b\,dt_b}{t_b^2} \quad \ldots\ldots (16)$$

$$dV = \frac{R_o}{t_o^2} - \frac{R_b}{t_b^2} = 0 \quad \ldots\ldots (17)$$

Equation 17 gives the optimum ratio of counting times for any rates; for the specific case of very low activity when R_o is approximately equal to R_b, the condition for optimum distribution of counting times is $t_o = t_b$.

Control of the Treatment of Water in Building Piping Systems

By Andrew T. Dempster

A paper presented on Sept. 24, 1952, at the Michigan Section Meeting, Battle Creek, Mich., by Andrew T. Dempster, Director, Bureau of San. Eng., Detroit Dept. of Health, Detroit, Mich.

PRACTICALLY everyone in this country accepts the safety of drinking water from public water supplies without question, because it is assumed that the treatment of every public supply is carefully controlled by competent plant and laboratory personnel. This confidence in public water supplies has grown as a result of public experience with safe water supplies that have decreased waterborne diseases to a negligible amount in the last half century.

With this record in mind, it is disturbing to those in the water works and public health fields to find that the careful control of the water treatment process at the source of public water supplies can be undone by careless supplementary treatment of the water within buildings before it is delivered to the final consumer outlet. The necessity for supplementary treatment of public water supplies has developed because of the desire of a building owner or caretaker to provide an adequate flow of water by removal of scale and to prevent leaks in the piping system due to corrosion. This practice of supplementary treatment, which has grown up especially in large office and apartment buildings, is not, of course, deliberately carried on by owners or managers in a manner which would endanger the building occupants' health. It is unfortunate, however, that both the method of introducing treatment materials and the chemical compounds themselves may be harmful to those consuming water so treated, although corrosion and scaling may be stopped or arrested in the piping systems by the action of these compounds.

In the early 1930's it came to the attention of the Detroit Dept. of Health, through the complaints of apartment residents, that the hot-water supply, and, in one or two buildings, the cold-water supply, were being altered in some way so that excessive foaming occurred when bath water was drawn, or the water had a color that differed from the normal city water.

Investigations of these complaints revealed that these unusual conditions were caused by the supplementary treating of the hot water or of both the hot and cold water in the buildings. It was also found that the method of introducing the treatment chemicals into the water piping system was very crude, and overdosage of chemicals could easily result. The feeders normally used were of the "pot" type, either with or without equalizing lines. Most of the chemical compounds in use had a greater specific gravity than water and would flow by gravity from the feeder into the hot-water distri-

bution system, or, in several buildings, directly into the main supply line of the building, so that both hot- and cold-water supplies were treated. It is readily apparent that the opening of the control valve on the feeder and the amount of the chemical in the reservoir were the two factors controlling the rate of chemical dosage into the water system.

The control valve and the refilling of the feeder were usually the responsibility of the building caretaker, or someone under his supervision, who generally did not have any training in this field and could not be expected to exercise the careful control needed.

It was also learned, by chemical analysis, that one of the chemical compounds used in the supplementary treatment of building water systems was potassium dichromate, a compound containing hexavalent chromium, which is toxic except in very minute quantities and is also considered to accumulate in the body. The presence of hexavalent chromium in excess of 0.05 ppm is sufficient for the rejection of a water supply according to the U.S. Public Health Service Drinking Water Standards (*1*).

In one building where both the hot- and cold-water supplies were treated with compounds containing potassium or sodium dichromate, the dosage was so high that the water seals in the toilet bowls were always yellow, regardless of the number of times they were flushed.

Possible Solutions of Problem

These complaints, coupled with the facts brought out in the department's investigations, caused the Detroit Dept. of Health to ask the aid of the departments of water supply and of buildings and safety engineering in finding a solution to the problem of supplementary treatment. A committee representing the departments examined three possible methods of solving the problem: [1] to make it illegal to add treatment chemicals to building water systems; [2] to treat the water supply at the water plant so that the necessity for supplementary treatment would be practically eliminated; and [3] to regulate the supplementary treatment so that proper equipment and personnel would be used.

The first method mentioned would be the easiest to accomplish as it would not be difficult to have the proper ordinances passed to make this practice illegal. If the reasons for using supplementary treatment in building water systems were not eliminated, however, the need for this treatment would still exist and would probably either result in the illegal treatment of water supplies in some buildings, or bring about pressure for the repeal of the ordinance at a later date.

The second alternative—treating the water supply at the city water plant—could be instituted only at a considerable expense by altering the treatment of the water supply at the plant to such a degree that the corrosion and scaling of water lines within the buildings would be kept at a minimum. The difficulty in this solution, in a large city particularly, would be the necessity—and consequent high cost—of treating the entire water supply although only a portion of the users actually required it. In Detroit there is no serious corrosion problem in the cold-water piping system, but the problem becomes pronounced when the water is heated, especially above 160°F, at which point

the breakdown of calcium bicarbonate causes corrosion and scaling.

After much deliberation, the committee decided that Detroit's most logical answer to this problem of supplementary treatment would be to regulate it.

Interim Solution

As an interim solution until an ordinance could be drawn up, a notice which contained a resolution adopted by the Detroit Board of Health on Nov. 2, 1938, was issued and attached to each water bill going to consumers having a 1½-in. meter or larger. This notice warned building owners not to add poisonous or deleterious compounds to the water system, either hot or cold, for the purpose of inhibiting or removing scale, rust, or corrosion, or for any other reason, unless devices for proper dosage under competent laboratory control were provided.

Many of the compounds then being sold to building owners were analyzed by the departments of health and water supply to see if they contained chemicals that would be dangerous in relatively small quantities when added to the water supply. The health department was particularly worried about potassium dichromate and found that one or two products did contain this compound. A warning was therefore issued to the effect that products containing this compound should not be added to water in the city of Detroit.

Various types of feeding devices were tested in the building department's plumbing laboratory. Also, information on the supplementary treatment of building water supplies in other cities was compiled. It was found at that time that no ordinance governing this treatment was enforced in any city of the United States, but that several cities, such as New York, were considering the passage of such an ordinance. New York did adopt one that became effective Apr. 1, 1939 (*2*).

Objectives

As a result of the health department's work, it was concluded that, to accomplish properly the regulation of supplementary treatment, it would be necessary to place a responsible person in charge of the treatment of each building's water supply system. This person would also have to be sufficiently qualified to recognize the possible hazards and take the necessary precautions. It was further decided that the operation of the dosing device for adding chemical material to building water systems would have to be practically foolproof. Thus, the device would have to treat the water in a definite proportion that could not be easily altered, and would continue to treat it proportionately regardless of changes in rate of flow.

It was further found that the type of dosing device commonly used in water treatment plants might become hazardous if there were any interruptions in the pressure available in the building water supply system, and it would therefore be necessary to design and manufacture the device in such a manner that only very small quantities of material could be siphoned from it when negative pressures were present in the city supply system. (Incidentally, there were no such devices on the market at that time). Lastly, it became apparent that the compounds used in supplementary treatment should be thoroughly checked and analyzed by a government agency before they were

certified for use by persons licensed to carry on supplementary treatment.

Ordinance

A tentative ordinance, which made the health department responsible for certifying the people that would engage in the supplementary treatment of water supplies, was drawn up with these three objectives in view. The health department examines an applicant, and if the examination reveals that he understands the problem of properly applying supplementary treatment and is otherwise qualified, he is recommended to the building department as eligible for licensing as a water treatment operator. The water department was made responsible for analyzing and certifying the chemical compounds used in supplemental water treatment, and the devices for applying the chemicals were to be tested and accepted by the department of buildings and safety engineering before they were installed by licensed master plumbers. Most of the enforcement procedures were also placed under the jurisdiction of the building department.

Dosing Device

Before the enactment of this ordinance in April 1943, many of the factors involved in its enforcement were carefully analyzed. The ordinance was reviewed with many of the persons already engaged in the water treatment business in Detroit and it was found that much difficulty would be encountered in procuring a dosing device that would meet all of the requirements thought to be necessary. In the tentative ordinance, it was stipulated that the treatment material should be supplied in sufficiently small quantities and at intervals to insure an average dosage (in each 10 gal of water being treated) not to exceed the specified maximum dosage allowed by the ordinance.

The device was also to be constructed so that it could not exceed the maximum dosage of the material that was to be added to the water unless the device was altered at the factory. These two provisions were necessary because some limitations had to be placed on the average dose, many of the pumps being either diaphragm- or piston-operated and working intermittently. It is conceivable that a proportional dosage requirement could be met even though the dosing equipment operated only once for every 1,000 or 2,000 gal of water that flowed by the device, instead of at the 10-gal interval established. It was also felt that the device should be made so that the proportioning mechanism could not be changed readily in the field; thus, a person without proper qualifications would not be able to increase the dosage.

It was necessary to apply the treatment to the cold-water makeup line to the hot water system, because, in larger buildings, most hot water systems recirculate the water. If treatment were applied to the discharge of the hot-water heating equipment, in off-peak hours the chemical concentration would build up to a concentration greater than the maximum established, as the water in the hot-water system is recirculated through the heater several times before it is actually used.

It was thought that some means of checking the accuracy of the dosing equipment was necessary and, therefore, the ordinance required that a visible gage be available to show the quantity of material present in the reservoir at any time and also that the water being treated be measured by a metering device, the device to

be constructed so that, in the event of a backflow or vacuum, the maximum amount of material that could be siphoned from the device or any of its attachments would not exceed 1 oz (fluid). The dosing device should automatically cease operating when a failure in the water metering device or the water supply occurs. This requirement has been construed to mean that the device should stop operating if a reversal of flow takes place. The ordinance also requires that the device be tested by the department of buildings and safety engineering before use in the city of Detroit is allowed. At the present time only two devices have been accepted.

Addition Compounds

The ordinance stipulates that no inorganic compounds should be used to increase the total alkalinity, total hardness, or total silica content of the water by more than 50 ppm, and that no organic compounds should increase the turbidity by more than 10 ppm (silica scale) and the color by more than 20 ppm, as determined by standard methods of water analysis. It was further required that any substances present in quantities that would be considered deleterious to public health must be reduced to a safe amount or eliminated.

It was stipulated that the chemicals be stored in metal containers acceptable to the department of buildings and safety engineering, and that these containers be kept locked, except when the reservoir of the dosing device was being refilled.

It was also stipulated that the enforcing officer may at any time require that samples of water be taken before and after treatment from test cocks provided for the purpose, and that these may be analyzed by the water treatment operator for increases in total alkalinity, hardness, and silica content if inorganic compounds are being added, and for increases in color and turbidity if organic compounds are being added.

Ordinance in Practice

The reasons for many of these requirements are already apparent from the objectives outlined in the regulations for supplementary water treatment. Later developments have shown that practically all of these provisions were necessary to regulate properly those engaged in the supplemental chemical treatment of water in building systems. In several buildings in which electrical methods were used, it was found that this ordinance could be invoked to control the treatment method.

The requiring of water meters met some opposition from the firms treating water in building systems. It has developed, however, that the water meter is an important addition in helping a building operator note how much hot water is being used. In several buildings severe losses of hot water during off-peak hours were noticed when the water meter was checked for consumption. It has also enabled the treatment operators to show the value of the treatment, as it can be demonstrated invariably that when the treatment process removes scale from the lines, the per capita consumption of water decreases in the building, probably because hotter water is delivered more quickly after the lines are cleaned, thus making it possible to use less hot water to accomplish the same results.

The dosing equipment that was used before the passage of the ordinance allowed many possibilities for the over-

treatment of building water supply systems. The inadvertent changing of a valve setting, the amount of material present in the reservoir, and the fact that these gravity devices worked whether there was any flow or not, were some of the things that could cause serious overdosing.

problems inherent in the old devices were surmounted. The siphonage problem was reduced to a minimum by pumping the chemical through an air gap and then repumping it.

Analyzing the chemicals and approving them for certification have presented problems because many different

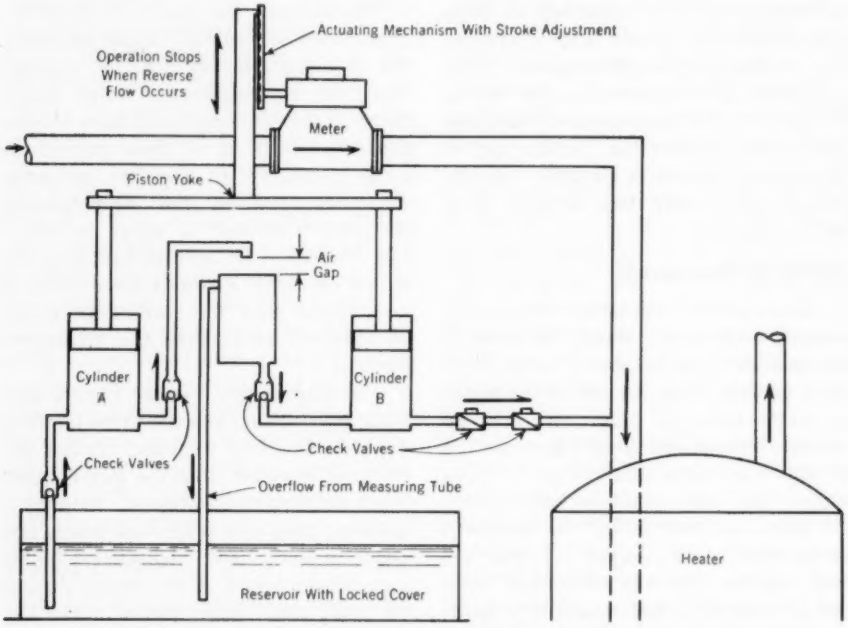


Fig. 1. Automatic Dosing Device Incorporating Protective Features

The chemical is pumped through an air gap and then repumped, thus alleviating the problem of back-siphonage. The maximum possible back-siphonage is 1 oz (fluid). The dosage is limited mechanically to 50 ppm. The actuating mechanism starts the pistons once for every 10 gal of water flow.

Even when a mechanical device controlled by a water meter but having only one pumping unit was used, there was a possibility of siphoning large quantities of material into the water system when a negative pressure due to an interruption in the service at some other point existed in the system. Figure 1 shows an acceptable device. Most of the

types of compounds have been submitted and it is sometimes difficult to compute the permissible limit of dosage. The most popular compound for treatment of hot-water systems is sodium silicate, and, fortunately, its optimum dosage rate of 8–30 ppm (*3*) is far below the 50-ppm increase in silica allowed in the ordinance.

Other Precautions

The Public Health Service Drinking Water Standards (*1*) definitely prohibit the addition of salts of hexavalent chromium for water treatment purposes, which precludes the use of potassium dichromate in water treatment compounds. Salts of barium and heavy-metal glucosides are also forbidden by these standards.

Another compound that has been proposed for use in hot-water systems is sodium sulfite, which reduces the amount of oxygen in the water system and thereby eliminates considerable corrosion. The amount of sodium sulfite required to eliminate corrosion in Detroit water is generally found to be on the order of 100 ppm. It is the health department's opinion, however, that it is dangerous to use this compound in water for human consumption in such quantities. The U.S. Dept. of Agriculture rendered an opinion years ago to the effect that sodium sulfite should be eliminated entirely as an additive to food products. Another hazard to health may exist in the high sodium content of water resulting from large doses of any sodium salt for water treatment purposes. This high sodium content might be hazardous to people on low-sodium diets who are unsuspectingly drinking beverages brewed with hot water or who are drinking hot water because of stomach disorders, for example. It has been shown by McGuire (*4*) that people on low-sodium diets can get a large proportion of their sodium intake from drinking water alone when the sodium content of the drinking water is greater than 50 ppm.

The quantities of molecularly dehydrated phosphates should be limited. The *Manual of Recommended Water Sanitation Practice* of the U.S. Public Health Service (*5*) suggests that the use of these compounds in excess of 10 ppm for treating any drinking water should be avoided. This amount is normally within the recommended dosage for effective treatment.

Still another precaution must be taken against introducing bacteriological contamination through the careless handling of the chemicals when filling the reservoirs of the dosing devices. The author believes that this problem alone is sufficient reason for demanding licensed operators.

There has been no attempt in this discussion to evaluate the efficiency of these supplementary chemical compounds in preventing scale formation or leaks in piping systems. There is much literature on this subject, and articles have appeared in the JOURNAL on such subjects as the efficiency of sodium silicate in inhibiting corrosion [Lehrman and Shuldener (*6*)], the use of sodium hexametaphosphate [Rice and Hatch (*7*)], and the treatment of hot water supplies at army posts [Kessler, Sundstrom, and Tomek (*8*)]. It should be pointed out that many of the building managements that started supplementary treatment of their hot-water systems ten or fifteen years ago are continuing to do so today, which would indicate that they consider the practice worth while.

Treatment chemicals can cause problems in water systems other than those relating to health. An overdosage of chemicals may cause a chemical plug to form at some point in a piping system, and it may also cause the quick release of scale and thereby plug shower heads and faucets. Again, it is necessary to exercise careful control; only an experienced or trained operator can prevent or minimize such occurrences.

All aspects of the proper regulation of supplementary treatment have not

been covered completely. Detroit's ordinance, however, has reduced the number of complaints received by the various municipal departments to a negligible amount. The health department realizes that there is probably some illegal treatment of water supplies in the city in spite of the ordinance, but it is felt that the ordinance has reduced the practice to a minimum.

Summary

Municipalities having public water supplies that are treated by the addition of supplementary chemical compounds in individual building piping systems have three possible methods to eliminate or minimize the health hazards which may result. These municipalities can eliminate the practice by: [1] making it illegal to add chemicals to private systems; [2] treating the water at the municipal plant, thus making additional treatment unnecessary; or [3] regulating methods and equipment and licensing qualified personnel to supervise the supplementary water treatment process. The regulatory method has been tried satisfactorily in at least two large American cities.

Acknowledgment

The author would like to acknowledge the efforts of William M. Wallace and Douglas Feben of the Dept. of Water Supply; L. Glen Shields and Elmo F. Liddle of the Dept. of Buildings and Safety Engineering; and F. Gardner Legg and Roger H. Chapin of the Dept. of Health, as it was the collaboration of these men and the departments which they represented, and the action of the city council, that brought about the control of supplementary treatment of water in building piping systems in Detroit.

References

1. Public Health Service Drinking Water Standards. *Pub. Health Rpts.*, **61**:371 (Mar. 15, 1946); *Jour. AWWA*, **38**:362 (Mar. 1946).
2. Rice, John L. Regulating Water Treatment in Buildings. *Jour. AWWA*, **31**: 81 (Jan. 1939).
3. Speller, Frank N. *Corrosion, Causes and Prevention.* McGraw-Hill Book Co., New York (3d ed., 1951). pp. 389–395.
4. McGuire, O. E. Water and Its Relationship to the Sodium Intake of Man. Proceedings of In-Service Training Course in Water Works Problems. Univ. of Michigan, Ann Arbor, Mich. (1951). pp. 20–26.
5. *Manual of Recommended Water Sanitation Practice.* Public Health Bul. No. 296, U.S. Public Health Service, Washington, D.C. (1946).
6. Lehrman, Leo, & Shuldener, Henry L. The Role of Sodium Silicate in Inhibiting Corrosion by Film Formation on Water Piping. *Jour. AWWA*, **43**:175 (Mar. 1951).
7. Rice, Owen, & Hatch, G. B. Threshold Treatment of Municipal Water Supplies. *Jour. AWWA*, **31**:1171 (July 1939).
8. Kessler, Lewis H.; Sundstrom, V. Bruce; & Tomek, Arthur O. Water Supply Practice in Army Training Centers. *Jour. AWWA*, **35**:1009 (Aug. 1943).

AWWA B202-52T

American Water Works Association

Tentative
Standard Specifications
for
QUICKLIME AND HYDRATED LIME

These "Specifications for Quicklime and Hydrated Lime" are based upon the best known experience and are intended for use under normal conditions. They are not designed for use under all conditions and the advisability of use of the material herein specified in any water treatment plant must be subjected to review by the chemist or engineer responsible for operations in the locality concerned.

Approved as "Tentative" by the AWWA Board of Directors
Sept. 9, 1952

AMERICAN WATER WORKS ASSOCIATION
Incorporated
521 Fifth Avenue, New York 17, N.Y.

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NOTE

These "Specifications for Quicklime and Hydrated Lime" were prepared under the direction of J. E. Kerslake for the Water Purification Division, AWWA. The specifications were approved by the Executive Committee of the Water Purification Division and by the Water Works Practice Committee, and received the approval of the Association's Board of Directors on Sept. 9, 1952. They were also submitted for review to producers and consumers of the materials involved, whose comments were then considered by Samuel Shenker, acting as referee.

Foreword

In these specifications there are presented five different methods of analysis for available calcium oxide content which have been found satisfactory for many years as bases for the purchase of lime for water treatment. Regardless of which method is preferred, usable results will be obtained only if the acid is carefully standardized, in accordance with such instructions as those included here, and if the procedure for the specific test is followed in exact detail.

Some water works men still believe that a better evaluation of lime can be made and more accurate results obtained by determining total calcium oxide (CaO). In addition to available calcium oxide, such an analysis determines calcium oxide present as calcium carbonate —a factor of little importance in water treatment. For those who prefer the total calcium oxide method, however, as well as for those who wish to make a complete analysis, the methods outlined in ASTM method C25 are recommended.

Not only are many different methods of analysis used, but some water works chemists prefer to use the average of more than one method in their evaluation of lime. The means of evaluation should be agreed upon between manufacturer and purchaser at the time of purchase.

In any evaluation method, it will be found that the amount of available calcium oxide varies in the limes sold by the many large manufacturers throughout the country. Such factors as source of rock, manufacturing conditions, and even personnel have an effect on the quality of the product. Because of the wide variation possible and because cost of transportation is at times an appreciable part of the price, purchase on a bonus and penalty basis has been recommended herein.

Similarly, a slaking penalty and bonus system has been specified for quicklime. As quicklime is fed through slakers, a lime that slakes readily is more economical to use and less difficult to handle in a treatment plant. In a number of plants where lime which does not meet the slaking requirements can be used satisfactorily, the slaking penalties may not be required. But even in these plants it will be wise to run a plant test before waiving the slaking penalty requirement.

In the specifications no limit has been set for magnesium, as it was felt that keeping the available calcium oxide content within the specified penalty-free limit would automatically take care of the problem. And although it was known that insoluble matter, iron, and aluminum can cause turbidity when lime is applied to a filtered water or one not to be filtered, no limit was set for these constituents because the difficulty with turbidity can be overcome by adding the lime as a saturated solution. If such a procedure is not practical, it may be necessary for individual plants to set up limits for insoluble matter and iron and aluminum oxides when purchasing lime, but such a condition occurs so rarely that inclusion of a provision for it in these specifications was felt unwarranted.

Likewise, no mention was made of the character of insoluble matter, on the assumption that its composition would be such that no trouble would be experienced in applying the lime by means of a dry-feed machine. And the specifications do not require the stamping of date of manufacture on the bags in which hydrated lime is shipped, on the assumption that the material will be delivered to the point of use in a condition to be handled readily in a dry-feed machine.

The specifications cover only limes composed mainly of calcium oxide or calcium hydroxide. Limes used for special purposes—such as dolomitic limes for removal of silica—are not included. Thus, for the purchase of lime of a different color or chemical composition, the specifications may be changed to provide the kind of material desired by the purchaser. The composition of such material should be agreed upon by the manufacturer and purchaser before shipment.

In the specifications for lime of any type, the purchaser may specify the method of manufacture to be used for making the material to be supplied.

Tentative Standard Specifications for

Quicklime and Hydrated Lime

Part A—Material Specifications

Sec. 1A—Scope

These specifications cover pebble, lump, or ground quicklime and hydrated lime for use in the treatment and softening of municipal and industrial water supplies. The specifications are intended for use in connection with Part B (Sampling, Inspection, Packing, and Marking) and Part C (Testing Methods) of this document.

Sec. 2A—Definitions

2A.1. Quicklime is the product resulting from the calcination of limestone or equivalent, such as dried water treatment sludge of suitable analysis, and consists essentially of calcium oxide or calcium oxide in natural association with a lesser amount of magnesium oxide.

2A.2. Hydrated lime is a very finely divided powder resulting from the hydration of quicklime with enough water to satisfy its chemical affinity. It consists essentially of calcium hydroxide or a mixture of calcium hydroxide and magnesium hydroxide, depending on the type of quicklime used in slaking.

Sec. 3A—Sampling

Sampling shall be conducted in accordance with Part B (Sampling, Inspection, Packing, and Marking) of this document.

Sec. 4A—Methods of Testing

The laboratory procedures shall be conducted in accordance with Part C (Testing Methods) of this document.

Sec. 5A—Impurities

5A.1. The quicklime or hydrated lime supplied under these specifications shall contain no mineral or organic substances in quantities capable of producing deleterious or injurious effects upon the health of those consuming the water which has been treated with it.

NOTE: The amount and nature of the fluoride compounds in lime supplied under these specifications shall be such that the fluoride content of the water as distributed to the consumer will not be increased more than 0.1 ppm by treatment with the lime.

5A.2. Quicklime shall be substantially free of core, ash, and dirt.

Sec. 6A—Rejection

6A.1. Notice of dissatisfaction with a shipment, based on these specifications, must be in the hands of the consignor within 10 days after receipt of the shipment at the point of destination. If the consignor desires a retest, he shall notify the consignee within 5 days of notice of the complaint. Upon receipt of the request for a retest, the consignee shall forward to the con-

signor one of the sealed samples (*see* Sec. 2B.2.2). In the event that the results obtained by the consignor, on retesting, do not agree with the results obtained by the consignee, the other sealed sample shall be forwarded, unopened, for analysis, to a laboratory agreed upon by both parties. The results obtained by the referee shall be accepted as final and the cost of the referee analysis shall be paid by the party whose results show the greatest discrepancy from the referee analysis.

6A.2. On the basis of the retest or the referee test, the consignor may remove the material from the premises of the consignee or a price adjustment may be agreed upon by the consignor and consignee.

Sec. 7A—Size

7A.1. Lime sizes are established to meet the requirements of various types of equipment, but purchasers may set size requirements to meet their own specific conditions if agreed to by the manufacturer.

7A.2. If the quicklime is to be fed by a dry-feed machine, it shall be crushed and screened so that none shall be retained on a $\frac{3}{4}$-in. sieve.

7A.3. If the quicklime is to be handled by pneumatic conveying equipment, it shall be crushed and screened so that none shall be retained on a 1-in. sieve and not more than 10 per cent shall pass a $\frac{1}{4}$-in. sieve.

7A.4. If the quicklime is to be handled by mechanical conveying equipment, the pieces shall be no larger than 2 in. in size, except that an occasional slablike piece may be up to 3 in. in length. Not more than 20 per cent shall pass a $\frac{3}{4}$-in. sieve and not more than 10 per cent shall pass a $\frac{1}{4}$-in. sieve.

7A.5. Hydrated lime shall be white, dry, finely powdered, and free from lumps and any foreign material which may interfere with the operation of dry-feed equipment. Uniformity of particle size is a desirable characteristic.

Sec. 8A—Bases for Purchase of Lime

8A.1—*Quicklime:*

8A.1.1. The purchase of quicklime shall be based upon an 88 per cent available calcium oxide content in the material furnished, with a scale of bonuses for a lime of available calcium oxide content above this percentage and a scale of penalties for a lime of available calcium oxide content below this percentage. The quicklime shall be of a quality known as "quick-slaking," shall slake satisfactorily, readily disintegrating into a suspension of finely divided material without the production of objectionable amounts of undissolved or unslaked material in the slaker, and in its purchase a scale of penalties and bonuses based upon the slaking test, procedure for which is given in Sec. 7C, shall also be applied.

8A.1.2. The bonuses and penalties based on available calcium oxide content shall be as follows:

(a) A *bonus* of 2 per cent for each 1 per cent, or fraction thereof, of available calcium oxide content greater than 88.0 per cent (from 88.0 per cent upward).

(b) A *penalty* of 1.5 per cent for each 1 per cent, or fraction thereof, deficiency of available calcium oxide content from 88.0 per cent down to and including 80.0 per cent available calcium oxide.

(c) A *penalty* of 2 per cent for each 1 per cent, or fraction thereof, defi-

ciency of available calcium oxide content from 80.0 per cent down to and including 75.0 per cent available calcium oxide content.

(d) The *basis for rejection* shall be an available calcium oxide content of less than 75.0 per cent.

8A.1.3. The bonuses and penalties based upon the slaking test (Sec. 7C) shall be as follows:

(a) A *bonus* of 1 cent per ton shall be paid by the consignee for each 2°C that the temperature rise produced by the lime exceeds the 40°C rise specified in the slaking test.

(b) A *penalty* of 1 cent per ton shall be exacted from the consignor for each 2°C that the temperature rise produced by the lime is less than the 40°C rise specified in the slaking test. This penalty ratio shall continue down to the point of rejection.

(c) The *basis for rejection* is the failure of the lime to produce more than a 10°C rise upon slaking in accordance with the slaking test.

8A.2. *Hydrated lime.* The purchase of hydrated lime shall be based upon a 66 per cent available calcium oxide content with a scale of bonuses for a lime of available calcium oxide content above this percentage and with a penalty scale for a lime of available calcium oxide content below this percentage. The bonus and penalty scales shall be as follows:

(a) A *bonus* of 1.5 per cent for each 1 per cent, or fraction thereof, of available calcium oxide content from 66.0 per cent upward.

(b) A *penalty* of 1.5 per cent for each 1 per cent, or fraction thereof, deficiency of available calcium oxide content from 66.0 per cent down to and including 62.0 per cent.

(c) The *basis for rejection* shall be an available calcium oxide content of less than 62.0 per cent.

NOTE: Purchasers may set up different bonuses and penalties to meet their own specific conditions if agreed to by the manufacturer.

8A.3. If the material warrants rejection, the manufacturer may remove the material or the material may be accepted by the purchaser at a mutually agreeable price.

Part B—Sampling, Inspection, Packing, and Marking

Sec. 1B—Scope

These procedures for the sampling, inspection, packing, weighing, and marking of quicklime and hydrated lime are intended for use with Part A (Material Specifications) and Part C (Testing Methods) of this document.

Sec. 2B—Sampling

2B.1. *Taking Samples.* Samples shall be taken expeditiously at the point of destination to minimize contact with air.

2B.1.1. If the material is handled by conveyor or elevator, a mechanical sampling arrangement may be used. Care must be taken to adjust the location and timing of sampling to secure a representative sample.

2B.1.2. With packaged material in cars or trucks, at least 2 per cent and no less than five of the packages shall be sampled. Individual packages shall be taken from various parts of the unit being sampled. No sample shall be taken from a broken package. The size

of the gross sample shall conform to the requirements of Sec. 2B.1.4. and 2B.1.5.

2B.1.3. On powdered packaged material, a sampling tube, such as a grain sampling tube, which takes a core not less than ½ in. in diameter, shall be used. The tube shall be inserted into the package being sampled so that it will take a core of the material from substantially the entire length of the package.

2B.1.4. In sampling lump material or finely divided material in bulk, a minimum sample of 50 lb shall be taken for each 30 tons of material.

2B.1.4.1. In sampling lump material in cars in bulk, sampling points must be selected uniformly over the surface of the bulk material. A minimum of ten points at regular intervals shall be selected.

2B.1.4.2. A convenient sampling system utilizes two elevations—such as: [1] 2 ft down from the top of the car; and [2] 2 ft up from the bottom of the car—and five points on each elevation —such as points approximately 3 ft in from each corner toward the center of the car and a point at the center of the car.

2B.1.4.3. Finely divided bulk material may be sampled by the use of a sampling tube, such as a grain sampling tube, which takes a core at least 1 in. in diameter. (Sampling tubes for this purpose can be obtained from laboratory supply houses.) A tube 5 ft long should be satisfactory. Cores shall be taken from at least ten separate parts of the mass in order to secure a representative sample.

2B.1.5. Sampling from truck bulk shipments can be done by retaining a shovelful from each truck loading 5 tons of lime or less, and two shovelfuls from two different points of trucks loading more than 5 tons. The samples thus collected shall be stored in an airtight container and a composite can be made of a day's shipment. The gross sample shall be thoroughly mixed and 16 lb of the material quartered to obtain the four sealed samples required by Sec. 2B.2 and the sample for the laboratory required by Sec. 2C.2.

2B.1.6. For small plants, if the delivery is in the range of 25–50 tons per week, a composite should be made of a week's samplings and retained in an airtight container. The test sample should be worked up from the container. If delivery is less than 25 tons per week, however, a sufficient sample —16 lb—should be obtained from each shipment to run an analysis.

2B.2. *Handling Samples.* Samples shall be selected and stored for analysis as follows:

2B.2.1. From the 50 to 70 lb of gross sample, approximately 16 lb, representative of the gross sample, shall be quartered. The remainder of the gross sample may be discarded.

2B.2.2. Four 1-lb samples shall be sealed in airtight, moistureproof glass containers. The samples shall be retained for 30 days after receipt of a shipment. One sample is for the immediate use of the consignee for his test of the shipment. The second and third samples are for the use of the consignor and referee laboratory if there is a controversy over the analysis. The fourth sample is for the use of the consignee as a check of the consignor's and referee's laboratory analysis. Each sample shall be labeled to identify it by such information as the name of the consignor, car number, and date received. Each label shall be signed by the sampler.

NOTE: Pint mason jars with adequate seals are satisfactory for storing samples.

Sec. 3B—Packing and Shipping

3B.1. Quicklime, either pebble, ground, or lump, may be shipped in bulk in freight cars or trucks, or in multiwall paper bags of 80-, 90-, or 100-lb net weight. The consignors shall protect themselves by an agreement, entered as a clause in their contract, with the carriers to secure their shipment intact.

3B.2. Pulverized lime may be shipped in bulk in cars or in 50-lb (net weight) multiwall paper bags.

3B.3. Hydrated lime may be shipped in bulk in cars or in 50-lb (net weight) multiwall paper bags.

3B.4. The net weight of packages shall not deviate from the recorded weight by more than 1.5 per cent, plus or minus. If exception is taken to the weight of the material received, the weight shall be based on a certified unit weight of not less than 10 per cent of the packages shipped and selected at random from the entire shipment.

3B.5. If equipment is available, the weight of bulk shipments should be checked. Payment should be made only for the weight of material received. To avoid any misunderstanding, an agreement to this effect should be made between the consignor and the consignee at the time the contract is let.

Sec. 4B—Marking

Each shipment of material shall carry with it some means of identification. Each package shall have marked legibly on it the weight of the contents, the name of the manufacturer, and a brand name, if any. The package may bear also the statement "Guaranteed by (name of manufacturer) to meet the specifications of the American Water Works Association for (quicklime or hydrated lime)."

Part C—Testing Methods

Sec. 1C—Scope

These methods for the examination of quicklime and hydrated lime are intended for use with Part A (Material Specifications) and Part B (Sampling, Inspection, Packing, and Marking) of this document.

Sec. 2C—Preparing Samples for Analysis

2C.1. Sampling shall be conducted in accordance with Part B (Sampling, Inspection, Packing, and Marking) of this document.

2C.2. The sample of quicklime for the laboratory shall be prepared from the remainder of the gross sample after the four 1-lb sealed samples have been set aside as described in Sec. 2B. The following procedure shall be used.

2C.2.1. Crush at least 0.5 lb to ¼-in. size using a mechanical crusher or, if none is available, a mortar and pestle.

2C.2.2. Pulverize mechanically sufficient ¼-in. sample to obtain 50 g of uniform sample that will pass a 100-mesh sieve. If mechanical equipment is not available, a mortar and pestle may be used.

2C.2.3. Store the pulverized sample in an airtight container.

NOTE: A 2-oz wide-mouthed bottle, similar to that used for bacteriological samples of water, is convenient, preferably if it is rubber stoppered. Corks are porous and ground-glass stoppers usually

stray away from their original bottles and, therefore, do not fit properly in the bottles with which they are used.

2C.2.4. Weigh each sample from the sample bottle rapidly to avoid excessive contact with air.

2C.3. Laboratory examination of the sample shall be completed within ten working days after receipt of the shipment.

2C.4. Samples shall be stored at least 30 days from the date of receipt of shipment before they are discarded.

Sec. 3C—Available Calcium Oxide Content

Available calcium oxide content in quicklime or hydrated lime is that constituent which enters into the reaction under the conditions of the specified method or process. A number of modifications in test procedures have been suggested and used by different workers. In the following description of these procedures, the lime sample specified is always that which passes a 100-mesh sieve, and the temperature at titration is always room temperature, 20°–25°C, unless otherwise specified.

3C.1—Sugar Method

3C.1.1—*Reagents:*

(a) 0.1*N* sulfuric acid.

(b) Carbon dioxide–free distilled water.

(c) Freshly prepared 10 per cent cane sugar solution in carbon dioxide–free distilled water (cane sugar is specified because lime is used in the production of beet sugar and the residual lime might affect the sugar test as a result of the ratio of sugar used to the quantity of sample used for analysis).

(d) Phenolphthalein indicator.

3C.1.2—*Procedure:*

3C.1.2.1. Weigh 0.5 g of sample rapidly and brush into a 250-ml Florence flask with the aid of a camel's-hair brush. Be sure to brush the funnel and stem thoroughly. Stopper tightly with a rubber stopper. A number of samples can be weighed successively in this manner. A short-stemmed funnel of about 50-ml capacity can be used to transfer the sample to the flask.

3C.1.2.2. Treat the sample with 100 ml of sugar solution by introducing 20–25 ml and dispersing it as much as possible with a light, twirling motion of the flask, and then pouring in the remainder rapidly. A volumetric flask certified to deliver 100 ml shall be used for the sugar solution.

3C.1.2.3. Stopper tightly and shake on a Camp rotary shaker (available at laboratory supply houses) for 1 hour, or shake occasionally by hand over a period of 2 hours. If the sample is to be shaken by hand, it is advisable to weigh 10 g of sugar, transfer it to the 250-ml Florence flask, transfer the 0.5-g lime sample, and mix the two dry; then add 95 ml of carbon dioxide–free distilled water, mix occasionally for 2 hours, and proceed with 3C.1.2.4.

3C.1.2.4. Allow to stand not less than 20 min, to settle most of the insolubles in order to aid rapid filtration.

3C.1.2.5. Filter through a dry No. 12 Whatman (or equivalent) folded filter paper. Do not expose the sample during filtration to an atmosphere abnormally high in carbon dioxide.

3C.1.2.6. Titrate 25 ml of the filtrate with 0.1*N* sulfuric acid using phenolphthalein indicator until the pink color is just discharged.

3C.1.3.—*Calculation:*

$$\text{Titration (ml)} \times 2.244 = \text{available calcium oxide (per cent)}$$

3C.2—Modified Scaife Method

3C.2.1.—*Reagents:*

(a) 1*N* and 0.1*N* hydrochloric acid.
(b) Phenolphthalein indicator.
(c) Carbon dioxide–free distilled water.

3C.2.2—*Procedure:*

3C.2.2.1. Place 1.4 g of lime sample in a 400-ml beaker and cover with 200 ml of hot distilled water. Cover with watch glass.

3C.2.2.2. Heat carefully, then boil for 3 min.

3C.2.2.3. Cool, wash down cover, then titrate with 1*N* hydrochloric acid using 2 drops of phenolphthalein indicator.

3C.2.2.4. As the colorless flash endpoint appears, retard the rate of addition of acid, then titrate until the pink color disappears for 2 sec.

3C.2.2.5. Place 1.4 g of lime sample in a 1-liter volumetric flask with a one-hole rubber stopper fitted with a short glass tube drawn to a point.

3C.2.2.6. Treat the sample with 200 ml of hot distilled water, heat carefully, and boil for 3 min.

3C.2.2.7. Cool, and place fifteen 4-mm clean glass beads in the flask and rotate until the sample is disintegrated.

3C.2.2.8. Add dropwise, with vigorous swirling, 5 ml less hydrochloric acid (1*N*) than the amount used under 3C.2.2.4. Call the number of milliliters of added acid, *A*.

3C.2.2.9. Dilute to the mark with carbon dioxide–free distilled water, and stopper with a solid stopper.

3C.2.2.10. Mix thoroughly for 5 min and allow to settle for 1 hour.

3C.2.2.11. Pipet 200 ml into a 500-ml Erlenmeyer flask, add phenolphthalein indicator, and titrate slowly with 0.1*N* hydrochloric acid. Call the additional quantity, in milliliters, *B*.

3C.2.3—*Calculation:*

$$\text{Available calcium oxide (per cent)} = 2A + B$$

3C.3—Ellms' Method

3C.3.1—*Reagents:*

(a) 0.1*N* sulfuric acid.
(b) Phenolphthalein indicator.
(c) Carbon dioxide–free distilled water.
(d) Cooper's indicator.

3C.3.2—*Procedure:*

3C.3.2.1. Weigh 0.5 g of lime sample into a 500-ml volumetric flask.

3C.3.2.2. Treat with 25 ml carbon dioxide–free distilled water and shake flask with a twirling motion to disperse sample.

3C.3.2.3. Treat with enough boiling distilled water to fill flask above the mark.

3C.3.2.4. Stopper with a rubber stopper and cool to room temperature in a water bath.

3C.3.2.5. Refill to mark with carbon dioxide–free distilled water.

3C.3.2.6. Shake on a machine, end over end, for ½ hour or by hand, end over end, intermittently for 1 hour.

3C.3.2.7. Allow to stand at room temperature for 48 hours.

3C.3.2.8. Titrate 50 ml of supernatant with 0.1*N* sulfuric acid, using phenolphthalein indicator. Call the number of milliliters of added acid, *A*. Add mixed bromcresol green–methyl red (Cooper's indicator) and complete the titration. Call the total number of milliliters of acid used, including those in the phenolphthalein titration, *B*.

3C.3.3—*Calculation:*

$$\text{Available calcium oxide (per cent)} = A - 5.61(B - A)$$

3C.4—Janzig Method

3C.4.1—*Reagents:*

(a) 0.1*N* sulfuric acid.
(b) Phenolphthalein indicator.
(c) Carbon dioxide–free water.
(d) Cane sugar.

3C.4.2—*Procedure:*

3C.4.2.1. Place 20 g of cane sugar in a 200-ml volumetric flask, preferably one with a wide neck, such as is used in the phosphate determination of fertilizers.

3C.4.2.2. Add 0.2 g of lime sample on top of the sugar, stopper, and mix sugar and lime intimately in the dry state.

3C.4.2.3. Make up to 200 ml with carbon dioxide–free distilled water.

3C.4.2.4. Shake on a machine, end over end, for ½ hour or by hand, end over end, for 1 hour.

3C.4.2.5. Allow to stand for 20 min to settle insolubles.

3C.4.2.6. Filter through a dry No. 12 Whatman (or equivalent) folded filter paper.

3C.4.2.7. Titrate 50 ml with 0.1*N* sulfuric acid using phenolphthalein as indicator.

3C.4.3—*Calculation:*

Titration × 5.61
= available calcium oxide (per cent)

3C.5—Graf's Method

3C.5.1—*Reagents:*

(a) 0.1*N* hydrochloric acid.
(b) Phenolphthalein indicator.
(c) Carbon dioxide–free distilled water.
(d) Cane sugar.

3C.5.2—*Procedure:*

3C.5.2.1. Make up 500 ml of a cane sugar solution containing 160 g of sugar in a 1-liter flask.

3C.5.2.2. Transfer 7 g of lime sample to the 1-liter flask containing the sugar solution.

3C.5.2.3. Shake on a Camp rotary shaker for 1 hour.

3C.5.2.4. Make up to 1 liter with carbon dioxide–free distilled water and shake by hand.

3C.5.2.5. Allow to stand overnight.

3C.5.2.6. Titrate 20 ml of the supernatant with 0.1*N* hydrochloric acid, using phenolphthalein indicator until the color is just discharged.

3C.5.3—*Calculation:*

Titration × 2
= available calcium oxide (per cent)

NOTE: ASTM method C25 may be used for analyzing the lime if the purchaser and the manufacturer agree that this method is satisfactory for evaluating the material supplied.

Sec. 4C—Standardization of Normal Acid Solutions

The following are methods for standardizing normal acid solutions referred to in these specifications.

4C.1—Standardization of 0.1N Sulfuric Acid

4C.1.1. It is advisable to check normal acid solutions by two different methods. Two methods suggested are those described below in Sec. 4C.1.2 and 4C.1.3.

4C.1.2—*Using sodium carbonate:*

4C.1.2.1. Heat 10–15 g of cp sodium carbonate in a porcelain or platinum crucible or dish, at 250°C for 2 hours, to remove the volatile matter; then cool in a desiccator. A muffle furnace may be found convenient for the heating.

4C.1.2.2. Weigh 5.300 g of the sodium carbonate, transfer to a 1-liter

volumetric flask, and make up to the mark with distilled water. This is a 0.1*N* solution.

NOTE: The remainder of the sodium carbonate can be returned to the reagent bottle.

4C.1.2.3. Make up the 0.1*N* sulfuric acid with 2.6 ml of concentrated sulfuric acid in a 1-liter volumetric flask and mix thoroughly.

4C.1.2.4. Titrate the 0.1*N* acid against 25 ml of the 0.1*N* sodium carbonate solution using mixed bromcresol green–methyl red (Cooper's) indicator.

4C.1.2.5. Calculate the factor of the acid solution as follows:

$$F = \frac{\text{sodium carbonate solution (ml)}}{\text{acid used in titration (ml)}}$$

Then dilute with the proper amount of distilled water to bring the solution exactly to 0.1*N*.

4C.1.3—*By precipitation with barium chloride:*

4C.1.3.1. Using the acid made up in 4C.1.2.3, measure out 10 ml from a buret into each of two 250-ml beakers.

4C.1.3.2. Dilute to approximately 100 ml with hot water and heat to boiling. Boil until the volume is approximately 25 or 35 ml.

4C.1.3.3. Treat with 5 ml of 10 per cent barium chloride solution, drop by drop, and continue boiling gently (this serves as agitation in lieu of stirring) for 5 min.

4C.1.3.4. Allow the precipitate to settle for at least 1 hour in a warm place, such as the low heat of a hotplate or on the partitions of a steam bath. This digestion accelerates the increase in size of the particles so that the precipitate can be filtered the same day instead of standing overnight at room temperature.

4C.1.3.5. Filter through a No. 42 Whatman (or equivalent) filter paper and wash with hot distilled water until free from chloride.

4C.1.3.6. Char the filter paper without flaming and ignite slowly until all the black specks of paper have been burned off. Then finish igniting by heating for at least 5 min at the full heat of a bunsen burner, or at 600°–700°C otherwise.

4C.1.3.7. Weigh and calculate the factor from the theoretical amount of barium sulfate that should be precipitated from 10 ml of 0.1*N* acid. The 10 ml of 0.1*N* sulfuric acid should give a precipitate of 0.1167 g of barium sulfate.

4C.1.4. The two factors—that obtained by standardization against sodium carbonate and that obtained by standardization against a precipitate of barium sulfate—should check within plus or minus 0.005.

4C.2—Standardization of 1N Hydrochloric Acid Using Sodium Carbonate

4C.2.1. Dry the sodium carbonate as directed in Sec. 4C.1.2.1.

4C.2.2. Weigh 1.060 g of the sodium carbonate and transfer to a 200-ml pyrex Erlenmeyer flask to which 80 ml of carbon dioxide–free distilled water has been added.

4C.2.3. Make up the 1*N* hydrochloric acid with 37.5 ml concentrated hydrochloric acid in a certified 1-liter volumetric flask and mix thoroughly.

4C.2.4. Titrate the sodium carbonate solution (4C.2.2) using Cooper's indicator.

4C.2.5. Repeat the procedure in 4C.2.2 and 4C.2.4 two times. The results of the three titrations should not

vary more than 0.1 ml, and the average of the three should be taken as the correct result.

4C.2.6. The acid has a normality of 1 when 20 ml of the acid is required in the titration. It will generally be found that less than 20 ml of the acid is required. Distilled water will have to be added to bring the solution to exact normality (between 1.005 and 0.995). After the acid has been adjusted to the exact normality it should be rechecked.

4C.3—Standardization of 0.1N Hydrochloric Acid Using Sodium Carbonate

4C.3.1. Dry the sodium carbonate as directed in 4C.1.2.1.

4C.3.2. Weigh 5.300 g of sodium carbonate and transfer to a certified 1-liter volumetric flask, making up to the mark with distilled water. This is a 0.1*N* solution.

4C.3.3. Make up the 0.1*N* hydrochloric acid with 8.3 ml concentrated hydrochloric acid in a certified 1-liter volumetric flask and mix thoroughly.

4C.3.4. Titrate the 0.1*N* acid against 25 ml of the 0.1*N* sodium carbonate solution using Cooper's indicator.

4C.3.5. Repeat procedure 4C.3.4 two times. The results of the three titrations should not vary more than 0.1 ml, and the average of the three titrations should be taken as the correct result.

4C.3.6. The acid has a normality of 0.1 when 25 ml are required in the titration. It will generally be found that less than 25 ml of the acid are required. Distilled water will have to be added to bring the solution to exact normality (between 0.1005 and 0.0995). After the acid has been adjusted to the exact normality it should be rechecked.

Sec. 5C—Indicators

5C.1. *Phenolphthalein.* Dissolve 5 g of cp phenolphthalein in 200 ml of warm isopropyl alcohol that has been neutralized to the phenolphthalein endpoint with 0.1*N* sodium hydroxide solution. Dilute to 1-liter with neutralized isopropyl alcohol.

5C.2. *Cooper's indicator.* Weigh 1 g of dry bromcresol green indicator on the balance watch glass, then weigh 0.2 g of dry methyl red indicator on top of this (or they can be weighed separately if desired) and dissolve in warm methanol. Make up to 1 liter with methanol.

NOTE: This indicator changes color at pH 4.5–4.6, or at approximately the same pH (4.4–4.5) at which methyl orange changes. If a titration is made carefully, a colorless endpoint, beyond which another drop or two will produce a faint pink color, will be obtained. The color of the concentrated indicator is reddish-orange. At the beginning of the titration the color is medium blue.

Sec. 6C—Carbon Dioxide-free Distilled Water

Boil distilled water in a flask, then stopper with a one-hole rubber stopper provided with an absorption tube filled with a granular mixture of sodium or potassium hydroxide and calcium hydroxide to absorb carbon dioxide from the air which will be drawn into the flask as the water cools. Cool in a water bath to room temperature. Keep the absorption tube in place as long as the water is to be used.

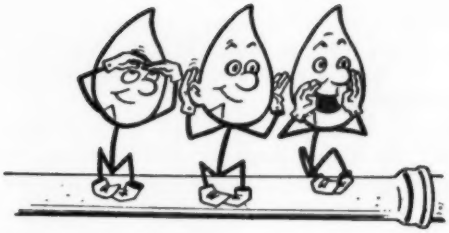
Sec. 7C—Slaking Test

Transfer 100 g of the gross sample retained in Sec. 2C to a porcelain casserole of 600–800-ml capacity (measuring 5½-in. in diameter and 3 in. in

depth) which contains 400 ml of distilled water at 25°C. A two-platform balance, with a sensitivity of 1 g, can be used to weigh the sample for this test. The sample can then be transferred from the balance pan to a piece of paper, then to the casserole. The sample is added to the water slowly with one hand while stirring slowly with a centigrade thermometer in the other hand. A stop watch is started after all the sample is added, and the temperature of the slaked lime solution is noted at the end of 3 min stirring as described previously. This temperature minus the 25°C starting temperature is the temperature rise upon slaking. It is well to mark at least the 25° and 65°C calibrations on the thermometer with a china-marking pencil in order to facilitate the reading of the final temperature.

Correction

In the article "Increasing Water Resources Through Weather Modification" by Irving P. Krick, which appeared in the November 1952 JOURNAL, the caption for Fig. 14 on page 1019 referred to Des Moines, Iowa. The correct location is Des Moines, *New Mexico.*



Percolation and Runoff

A Happy New Year brings what we hope you will agree is a happy new look to the JOURNAL and to P&R. Resolution behind all the moving and maneuvering was to increase not only the proportion, but the actual number, of pages devoted to technical papers while limiting increase in expenditures to the 10 per cent attributable to price increases and circulation growth. Transfer of some ads to the front of the Journal, double-columning of all the P&R material, and postponement of the membership change listings until the new annual issues of the Directory, are the basic economies which will make this possible. But, as usual, there's more to this than greets the eye —more cooperation, that is, by all advertisers in general and by Lock Joint Pipe Co. and Industrial Chemical Sales Div. in particular.

With a larger front section, it became necessary to move the Contents page to a readily findable position—page 1. And to make that possible, Lock Joint yielded its position of the past 21 years to set up shop on page 3, where it begins this, its 28th, year as first advertiser in the Journal. Meanwhile, Industrial Chemical Sales, which had kept company with the Contents since way back in 1939 was cooperative enough to move across the tracks and take up residence as first ad in P&R, where they'll be found beginning now.

And so it grows—with the Association, with its advertisers, with its readers, and with its contributors.

A date with May is even better than it sounds—and you've got one for the next four years at least. May is the month, of course—the month of AWWA's annual conferences—and so that you won't double-date her, you ought to calendar these weeks right now:

1953	May 10–15	Grand Rapids, Mich.
1954	May 23–28	Seattle, Wash.
1955	May 1–6	Atlantic City, N.J.
1956	May 6–11	St. Louis, Mo.

"From ours to mine" isn't the tale of an excommunist at all, just the story of a group of Westville, Ill., sportsmen who appreciated the value of water as a recreational facility. The "ours" was not only $45,000, but a great deal of time and effort that the sportsmen put into the creation of a 28-acre artificial lake. The "mine" was an abandoned one on the lake site. And the pains came when the open shaft of the mine made like a drain. Tennis, anyone?

(Continued on page 34)

(Continued from page 32)

Respectability is the word for rainmaking these days, and what an unhappy word it is—dull, disinteresting, distasteful! Respectability it is that has delivered our cloud busters into the hands of AWWA Task Group E2.A, that has enticed them away from P&R with a mere lion's share of the text section of the November 1952 JOURNAL (pp. 996–1020), 35 puny pages in the *Proceedings* of the UN scientific conference, 19 in the November General Electric *Review*, a feature story in the *Wall Street Journal*, and an editorial in the *Old Farmer's Almanac*. Respectability it is that is turning their heads with not just credit, but blessings, for averting catastrophes in the tobacco lands of Connecticut and the oil lands of Texas in quick succession. Respectability it is that has permitted them to extend their wonder working around the world. And respectability it is that is driving us into the camp of their competitors.

A little less respectable, we like to think, was the man who pioneered cloud seeding more than a hundred years ago in driest Africa. This was Dr. Sechele, acknowledged top medicine man of his continent and friend of David (the presumed) Livingstone. It was Sechele who really devised the present ground seeding technique in generating his nuclei in a fire to the windward of the cloud to be coaxed, and letting them go up in smoke. As a matter of fact, the only real difference between Dr. Sechele's 1850 technique and that of General Electric's Dr. Vonnegut today is that the latter has substituted silver iodide for Sechele's concoction of "charcoal derived from burned bats, deposits of the mountain cony (*Hyrax capensis*), jackals' livers, baboons' and lions' hearts, and serpents' skins and vertebrae, together with every kind of tuber, bulb, root, and plant to be found in the country." Can you even question which we find the tastier?

Actually, though, we need go back no further than last fall and away no further than Anadarko, Okla., to elude respectability. Then and there it was that Chief Juan Gachupin of the Jemez Apache Indians induced a cloudburst with the dust of his rain dance. Again, what the Gachupin method lacked in respectability it more than made up in antiquity, and what more could anyone ask than a cloudburst from a clear sky?

It'll be a sad day when P&R is mistaken for Propriety & Respectability.

It's the rampancy of respectability, though, that really has us worried. If it were just rainmaking, we could forgive and forgo, but that appears to be only the beginning. Just last month we were accused of scoffery unbecoming a scientific methodist in our attitude toward what we persist in regarding as the newest wrinkle in dowsing—the welding rod pipe pointers. And now that a full-fledged, college-faculty-staffed research project is under way, we hasten to hold our fire until the final reckoning. Meanwhile, it will perhaps help speed the reckoning if the rodicals among us request from Mr. C. W. Haffenreffer, Radiesthetic Locator Research Laboratory, Elmwood Station, Providence, R.I., a copy of the questionnaire he is distributing to those who wish to record their experiences with the rods.

While the rods are presumably teetering on the balance of respectability, then, we must seek refuge again in the so far unchallenged disrespectability of the quasi-electronic divining rod invented by V. A. Clarkson of Raleigh, Miss., as a device to point out the hidden hoards of gold and valuables buried by Southerners during the Civil

(Continued on page 36)

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(Continued from page 34)

War. What deprives the Clarkson goldmaster of respectability, actually, is the fact that, although there are approximately 150 in use in Mississippi today, Clarkson claims "they are wildcatters . . . mine is the only accurate machine I know of." That, and perhaps the fact that even in his one success so far, the $60,000 unearthed was stolen from him before he had a chance to show it to anyone. Water works men, of course, have billions of dollars hidden underground.

Water's powers, so often extolled in these columns, have just about overearned our admiration. Scene of the latest miracle is a 20,000-acre plot in Cumberland and Salem Counties, N.J., on which Seabrook Farms have located the nation's largest combined truck farm and frozen food factory. Miracle on the scene is a junior-size jungle created merely by taking a scrub oak lot and adding water. Of course, the water added up to an equivalent of 1,200 in. rainfall per year, this amount in waste process water being sprayed upon the woodland floor in quantities up to 12 mgd to give New Jersey not only the wettest spot on earth but perhaps its densest jungle.

At the bottom of the upjunglement was a serious waste water disposal problem on which the Seabrook organization was about to spend a million dollars when Johns Hopkins Univ. climatologists stationed at the farm suggested spraying the water back on the land. When an open clover field just couldn't take it, the sprays were set up in a small wooded area, which seemed to soak up any amount of water as fast as it fell—as much as the equivalent of 50 in. of rain in a 10-hour period.

"Today," reports the National Geographic Society, "it is as if the woods cannot grow fast enough. Seeds germinate that would otherwise have been dormant. Small shrubs and vines twist together into a solid mat of greenery. Through the jungle woods run far larger than normal numbers of small animals such as wood mice. . . . The U.S. Geological Survey is interested in the effects of the spraying on ground water levels in the surrounding area. Seabrook Farms is trying to unravel the secret of why the woods will soak up so much water while open fields of the same soil will not. What had farming done to the soil? Can field crops be improved with tremendous doses of water?"

In our infinite faith in water's powers, we're willing to predict that more water will grow more peas, potatoes, beets, and, even spinach, as well as more woods to hold back more flood waters. Not just "Just Add Water" any more, but "Pour me a jungle!"

Correction please! Hood, as in *hell,* not Wood, as in *well,* is the name of the vice president (initials, C. K.) of Worthington Corp., who was listed as Associate Member representative on P&R p. 36 of the November issue.

(Continued on page 38)

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(Continued from page 36)

James H. McCambridge, superintendent and general manager of the Burbank, Calif., Public Service Dept., died on November 4, 1952, at the age of 61. He had joined the department in 1924 and by the next year had been promoted to the post he held at the time of his death. He held that responsibility continuously, except for a short period in 1952 during which he served as city manager. Ill health forced him to relinquish the post, however, and return to the Public Service Dept.

John R. Barnes, Iowa Section Fuller Award Nominee and representative for the Neptune Meter Co. in Iowa, died on Nov. 13, 1952, at the age of 57. He had been in failing health for some time. He had joined the Neptune organization in 1924 and was a member of its 25-Year Club.

F. F. Osborne has joined the Smith-Blair staff as general sales manager, with headquarters at South San Francisco, Calif. Previously he had been with Fairbanks-Morse Co., Byron Jackson Co., the Corps of Engineers (in a civilian capacity), and before coming to Smith-Blair had been an independent consultant.

"Spiral-Glas" is the name of a new pipe made of Fibreglas strands imbedded in a polyester resin. Made by Bettis Corp., P.O. Drawer 9365, Houston, Tex., the pipe is said to have high tensile and bursting strength and is furnished in 20-ft lengths. At present, only 2- and 4-in. sizes are available.

(Continued on page 40)

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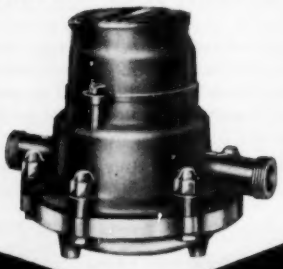

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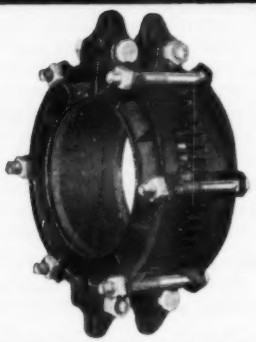

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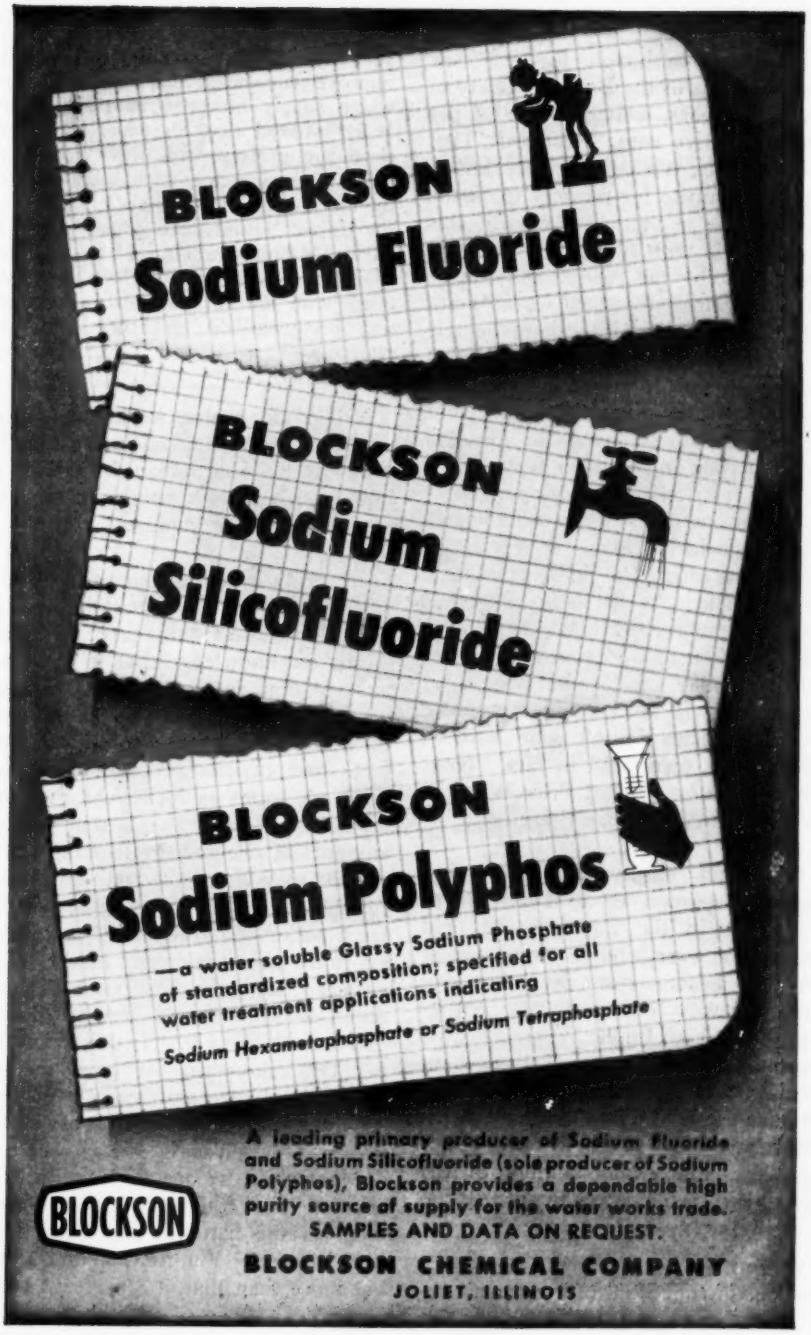

BLOCKSON
Sodium Fluoride
BLOCKSON
Sodium
Silicofluoride
BLOCKSON
Sodium Polyphos
—a water soluble Glassy Sodium Phosphate of standardized composition; specified for all water treatment applications indicating
Sodium Hexametaphosphate or Sodium Tetraphosphate
A leading primary producer of Sodium Fluoride and Sodium Silicofluoride (sole producer of Sodium Polyphos), Blockson provides a dependable high purity source of supply for the water works trade.
SAMPLES AND DATA ON REQUEST.
BLOCKSON
BLOCKSON CHEMICAL COMPANY
JOLIET, ILLINOIS

(Continued from page 38)

Another resolution for the new year was that of the Boston Society of Civil Engineers, which, by a 91.7 per cent affirmative vote, *"Resolved:* That it is unethical for an engineer knowingly to compete for services to clients on the basis of price." Actually, this is of a piece with the earlier stand on the subject by the ASCE and constitutes a warning to water works management together with other clientele that engineering isn't a commodity to be shopped for or bought on low bid. That's as it should be, of course, but what it unhappily brings to mind is the tight shoe on our other foot. With no such restriction on employers competing for engineers, water works management is feeling more than a slight pinch in its attempt to enlist new talent for the field. What with companies such as General Electric taking to radio and television to woo young engineers with promises of future, fame, and fortune, it will be a wonder if every young graduate doesn't soon have to measure his own head in feet. Next thing you know, "What Price Water?" will mean "What Price Engineers?"

Not just engineers, either, but trained employees of all kinds are of a scarcity in the water works field these days, everywhere. A visitor at AWWA headquarters the other day from faraway Formosa, one Yung-Mao Liu, Chief, Public Works Section, Dept. of Reconstruction, Taiwan Provincial Govt., who has been visiting the world as a UN public administration fellow interested primarily in developing the public water supply of the island, had this to say in the conclusion to his report:

Everywhere in the world there is a shortage of trained men for economic development. The first thing to do in the improvement and development of Taiwan water supply must be to train MAN. It is believed that an experienced, enthusiastic professor of water supply or sanitary engineering should be engaged by the Technical Assistance Service of the United Nations or by the Mutual Security Administration of the United States and invited to Taiwan to collaborate with the various local institutions and organizations concerned with the training of more and better qualified WATERMEN.

When any water works man anywhere comes to the conclusion that he needs MAN more than MONEY to develop his system, things must have come to a pretty impasse.

Fluoridata having opened our eyes to the condition of our mouths, we are now alert to oral statistics of all kinds. Thus, the knowledge that in 1951 we as a nation spent $1,620,000,000 on candy and only $1,000,000,000 on dental care gave us a clue to still another fact—that cavities occur in children's teeth six times as rapidly as they are repaired. Further word that minute amounts of selenium in drinking water or food may also make teeth more susceptible to dental decay has us visualizing a nation of sweet-toothed gumbeaters in the none too distant future. The answer, says the American Dental Assn., must be even more than fluoridation—which at best is only some 65 per cent successful—it must include good dental care and some intelligent self-restraint on the part of tooth-owners themselves.

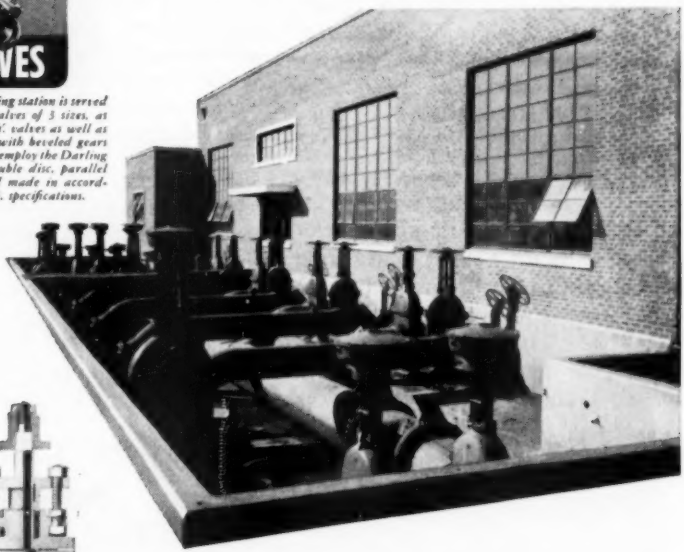
Meanwhile, we are all too willing to estimate that there are more sound teeth in the nation today than there were last year. Fluoridation, of course: but more than that, 1.7 per cent more

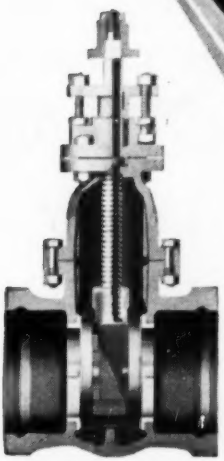
(Continued on page 42)

DARLING VALVES

FOR PLUS VALUES, JOB-PROVED AGAIN AND AGAIN

This modern pumping station is served by Darling gate valves of 3 sizes, as shown—20" O.S.&Y. valves as well as 30" and 36" sizes with beveled gears and gear cases. All employ the Darling fully revolving, double disc, parallel seat principle, and made in accordance with A.W.W.A. specifications.





Note rugged simplicity of this unique Darling principle—just four sturdy working parts . . . two plain interchangeable no-pocket discs and two bushy wedges. Assembly and maintenance is extremely easy and foolproof.

Time and money ahead

THIS new municipal pumping station gains a unique advantage proved in hundreds of similar operations throughout the country. Because these gate valves are Darlings . . . *featuring Darling's fully revolving, double disc, parallel seat principle* . . . the city as well as the water department will be time and money ahead years on end.

If you haven't yet checked into Darling gate valves of this type (shown in cutaway view at left) we'd like to give you *all* the facts on the distinctive features that always add up to . . .

1. Positive, easier closing. 2. Automatic adjustment for valve body distortion. 3. Elimination of disc-to-seat galling. 4. Uniform wear distribution. 5. Greater service life with far less maintenance.

SEND FOR BULLETIN

Darling's latest bulletin is full of helpful information and describes Darling valves of *all* types for every normal or unusual service.

DARLING VALVE & MANUFACTURING CO.

Williamsport 23, Pa.

(Continued from page 40)

mouths, running the present total to 157,505,000—an increase of 6,373,000 since the April 1950 census.

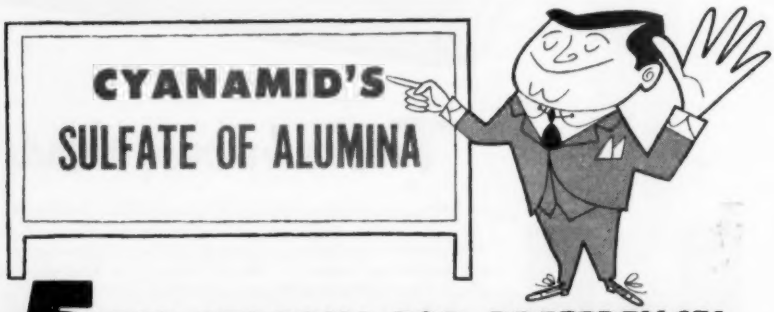
Construction permits and controlled materials allocations for 450 water works construction projects valued at $215,500,000 were approved by NPA for the third quarter of 1952. An additional $127,500,000 worth of sewage works was also approved in 253 projects.

D. Birney Stokes, vice-president in charge of sales for United States Pipe & Foundry Co., has retired after 42 years of service with that organization. He has been salesman, sales agent, eastern sales manager, western sales manager, general sales manager, vice-president (since 1926), and director (since 1928). He is being succeeded by Charles S. Northen.

In another personnel shift announced by the firm, Carl N. Brown has been appointed sales manager for cast-iron pipe. Brown, who is also the current president of the Water & Sewage Works Manufacturers Assn., was serving as assistant general sales manager before his promotion.

A century, rather than an annual report, has been issued by the Pennichuck Water Works of Nashua, N.H., on the completion of its first hundred years. For the next hundred years, if there is any truth in proverbs, things should be easier for Supt. Donald C. Calderwood and those who share his headaches.

(Continued on page 44)



5 BIG REASONS FOR PREFERENCE!

Waterworks superintendents who depend on Cyanamid's Sulfate of Alumina know these five big reasons for its widespread use:

1. **Uniform, trouble-free feeding**
2. **Wide pH range of coagulation**
3. **Rapid floc formation**
4. **Maximum adsorption of suspended and colloidal impurities**
5. **Minimum corrosion of feeding equipment**

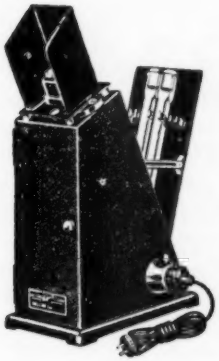
Write today for all the details on how these advantages can help you.

AMERICAN Cyanamid COMPANY
Heavy Chemicals Department
30 Rockefeller Plaza, New York 20, N. Y.
In Canada: North American Cyanamid Limited, Toronto and Montreal

For Precise FLUORIDE TESTS

USE THE PERMANENTLY RELIABLE

HELLIGE Aqua TESTER



GUARANTEED NON-FADING Glass Color Standards • Test based on official A.P.H.A. and A.W.W.A. procedure • Built-in illumination makes determinations always independent of time or weather • Stable components assure fresh, dependable reagent.

MODERN HELLIGE INSTRUMENTS

- ▶ TURBIDITY MEASUREMENTS
- ▶ WATER ANALYSES
- ▶ pH CONTROL
- ▶ COMPLETE SOLUTION SERVICE

WRITE FOR YOUR CATALOGS TODAY

Please Send FREE Catalog Set No. 600-W

NAME.....

STREET.....

CITY..... STATE.....

HELLIGE, INC. 877 STEWART AVE. GARDEN CITY, N. Y.

(Continued from page 42)

Eugene Schmidt has been appointed chief engineer of Refinite Corp., Omaha, Neb., coming to that organization from the Dorr Co.

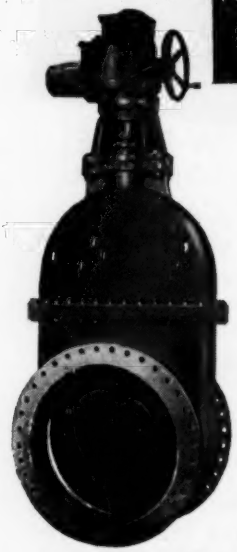
To pH add pU in the list of distinctly water works terms. Not nearly as complicated as pH, the new term first appeared in this headline from the Geauga (Ohio) *Times-Leader:*

Burton's Water Rates Scheduled to Go pU

Before coming to terms, though, we ought to complain about editorializing on the news pages.

Scare headlines are tame compared to the recent national advertising of one of our best known plumbing supply houses. It was in the *Saturday Evening Post,* as a matter of fact, that we spotted the characteristic smoke pattern of a Hiroshima and found this text silhouetted against it: "Like an ATOM–IC explosion, just one pinhole size faucet leak mushrooms into atomic waste of approximately 95,000 gallons of water yearly—costing $24.14." Evidence of the kind of care we like to see in advertising is the note that the figures had been authenticated by the Hackensack Water Co. As a matter of fact, we who would go to almost any ends to promote conservation, like the idea on the whole, but would be happy to settle for something just a little less lurid. Oh yes! Object of the ad was a faucet washer!

(Continued on page 46)



LIMITORQUE
VALVE CONTROLS

From coast to coast, hundreds of LimiTorque Controls are in service in water works and sewage disposal plants for automatic or remote operation of valves up to 120 inch diameter. Why is acceptance so widespread? Because LimiTorque Operators are designed to provide dependable, safe and sure valve actuation at all times.

LimiTorque is self-contained and is applicable to all makes of valves. Any available power source may be used to actuate the operator: Electricity, water, air, oil, gas, etc.

A feature of LimiTorque is the torque limit switch which controls the closing thrust on the valve stem and prevents damage to valve operating parts.

Write for Catalog L-50 and get the details

PHILADELPHIA GEAR WORKS, Inc.
ERIE AVENUE and G STREET, PHILADELPHIA 34, PA.
New York • Pittsburgh • Chicago • Houston • Lynchburg, Va.

this MARK OF QUALITY IS YOUR PROTECTION ON CAST IRON PIPE

This Q-Check trademark is a symbol of quality stenciled on all McWane-Pacific Super-DeLavaud cast iron pipe. It is your assurance that the pipe you lay is used and approved by leading independent laboratories and engineering associations. Only Cast Iron Pipe meeting the most rigid inspection is permitted to use this Q-Check trademark.

The "Q-Check" trademark is registered in the United States Patent Office by the Cast Iron Pipe Research Association as a service trademark signifying scientific quality-control in the manufacture of cast iron pipe. It is a symbol of the service of McWane-Pacific cast iron pipe, which "serves for centuries."

PRECALKED
•
OPEN BELL-AND-SPIGOT
•
MECHANICAL JOINT
•
FLANGED

McWANE Cast Iron Pipe Company
Birmingham, Ala.
Pipe Sizes 2" thru 12"

Sales Offices

Birmingham 2, Ala.	P. O. Box 2601
Chicago 1, Ill.	333 North Michigan Ave.
New York 4, N. Y.	80 Broad Street
Kansas City 6, Mo.	1006 Grand Avenue
Dallas 46, Texas	Maple Avenue Office Bldg.

PACIFIC STATES Cast Iron Pipe Co.
Provo, Utah
Pipe Sizes 2" thru 24"

Sales Offices

Provo, Utah	P. O. Box 18
Denver 2, Colo.	1921 Blake Street
Los Angeles 48, Cal.	6399 Wilshire Blvd.
San Francisco 4, Cal.	235 Montgomery St.
Portland 4, Oreg.	501 Portland Trust Bldg.
Salt Lake City	Waterworks Equip't Co.
Seattle 4, Wash.	1806 Smith Tower Bldg.

(Continued from page 44)

Modern design has moved into a lot of new places of late, but nowhere has it more surprised or pleased us than in the publications of the Kentucky State Dept. of Health. In both format and technique, the monthly *Bulletin* and the monthly *News and Plans* do a "professional" job of selling health and of convincing the reader that the department is sold on its slogan: "Kentucky's greatest resource is her people." Recent issues with such titles as "I Was a Cancer Patient" educate Kentuckians in stories interesting to all in language understandable to all, and the annual report on department facilities presented under title of "The Big Question" in the October 1952 *Bulletin* uses a technique that might well be adopted by water works in selling their bill of goods. In simplest terms, Kentucky is stressing "public" as well as "health" in public health, and thereby ought to be able to do more more easily.

French literature ought to be in for another golden age at the end of this year. That's when the famous sewers of Paris will finally be restored to their "classic condition," at the completion of the huge rebuilding program aimed to make up for wartime neglect. French tourist traffic is due to boom, too, for weekly boat trips will be operated through at least part of the sewer system during the summer months. The fascination, as we understand it, is the hunt for a body, not a BOD. We'll stick to water systems, as at least a little less miserable.

SPARLING
Main-Line Meters

Accurate main-line measurement is the key to efficient operation

Descriptive Bulletin 311 comes on request

SPARLING METER COMPANY

LOS ANGELES 54 ..... Box 3277
CHICAGO 8 ..... 1500 S. Western Ave.
CINCINNATI 2 ..... 626 Broadway
NEW YORK 17 ..... 101 Park Avenue
BOSTON 8 ..... 6 Beacon Street
SEATTLE 1 ..... 1932 First Avenue
DALLAS 1 ..... 726 Reserve Loan Life Bldg.
ATLANTA 3 ..... 66 Luckie St. N. W.
KANSAS CITY 6 ..... 6 East 11th St.

6 Reasons why
PALMER SURFACE WASH SYSTEMS
are specified by water works engineers

1. Prevent Sand Beds From Cracking.
2. Eliminate Mud Balls.
3. Save Wash Water.
4. Lengthen Filter Runs.
5. Higher Rates of Filtration.
6. Better Tasting Water.

Write today for Bulletin 451 and a list of water purification plants that have gone modern.

STUART CORPORATION
516 N. CHARLES ST. BALTIMORE 1, MD.

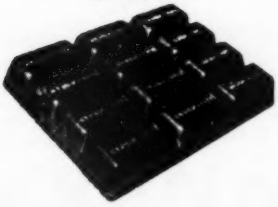
just a reminder that -

A pipeline is no stronger than its joints.

POWDER OR PIGS—WITH FIBREX MAKE PERFECT JOINTS
Working Samples on Request.

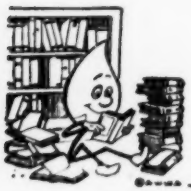
HYDRO-TITE (POWDER)

HYDRO-TITE (LITTLEPIGS)



FIBREX (REELS)

HYDRAULIC DEVELOPMENT CORPORATION



The Reading Meter

Proceedings of the United Nations Scientific Conference on the Conservation and Utilization of Resources. Vol. IV—Water Resources. *Dept. of Economic Affairs, United Nations, New York (1952) 466 pp.; paperbound; $4.50 from International Documents Service, Columbia Press, 2960 Broadway, New York 27, N.Y.*

This volume collects the technical papers presented at a conference held August 17 to September 6, 1949, and represents an exhaustive summary of human knowledge on many topics. The main subdivisions are: The Appraisal of Water Resources, Water Supply and Pollution Problems; Comprehensive River Basin Development; Water Control Structures; Flood Control and Navigation; Irrigation and Drainage; and Hydro Power and Other Water Uses. These categories give but a hint of the scope of the volume, however, which contains in nearly 500 oversized pages as much as the average 1,500-page book could hold. Well and fully illustrated.

The Nile: A general account of the river and the utilization of its waters. *H. E. Hurst. Constable & Co., Ltd., London (1952) 326 pp.; available in U.S. from Macmillan Co., New York, at $6*

Although scarcely required reading for those who refuse to be diverted from strictly business matters, many water works men may find that their occupational preoccupation with water—if we may put it that way—will lend appeal to this discussion of a river which has excited the imaginations of men since remote antiquity. The discursiveness of the author—who is concerned equally with the exploration of the sources, the relationship with ancient and modern populations, and the hydrology and industrial exploitation of the river—will make the book even more agreeable to the casual reader.

Quantitative Analysis: Elementary principles and practice. *Harvey Diehl & G. Frederick Smith. John Wiley & Sons, Inc., New York (1952) 539 pp.; $5*

Although primarily intended as a text for students, this volume gathers together much information on new developments —such as the Schwarzenbach procedure for determining total hardness and developments in colorimetry—thus making it a useful single source of information and reference.

The Ground-Water Resources of Wayne County, New York. *R. E. Griswold. Bul. GW-29, State Water Power & Control Com., Dept. of Conservation, Albany, N.Y. (1951) 61 pp.; paperbound; free*

The report was prepared by the U.S. Geological Survey as a state-federal cooperative project.

The Ground-Water Resources of Schenectady County, New York. *E. S. Simpson. Bul. GW-30, State Water Power & Control Com., Dept. of Conservation, Albany, N.Y. (1952) 110 pp.; paperbound; free*

Another state-federal cooperative report.

(Continued on page 50)

FOR DEPENDABLE FLOW CONTROL...

Specify KENNEDY Iron-Body Double-Disc Gate Valves for Water Service

Check your Valve requirements against this handy chart: NOTE: 3" thru 48" are all A.W.W.A. Standard

TYPES OF VALVES AVAILABLE—Non-rising Stem and Outside Screw & Yoke

Connections Available	*2"—6"*	*8"—14"*	*16"—24"*	*30"—60"*
Bell Ends	Yes	Yes	Yes	Yes
Screwed	Yes	Yes	No	No
Flanged	Yes	Yes	Yes	Yes
Mechanical Joint	Yes	Yes	No	No
Universal	Yes	Yes	Yes	30" only
Transite	Yes	Yes	Yes	30"-36" only
Spigot Ends	Yes	Yes	Yes	Yes
Combination Ends	Yes	Yes	Yes	Yes
Accessories Available	*2"—6"*	*8"—14"*	*16"—24"*	*30"—60"*
Rollers for Horizontal Operation			Bronze on bronze track	Bronze on bronze track
Stem and Stem Nut	Manganese Bronze 60,000 lb. Tensile strength	Manganese Bronze 60,000 lb. Tensile strength	Manganese Bronze 60,000 lb. Tensile strength	Manganese Bronze 80,000 lb. Tensile strength
By-Pass			available	available
Spur Gears			available	available
Bevel Gears			available	Standard
Gear Cases			available	available
Electrical Control	available	available	available	available
Cylinder Control	available	available	available	available
Square Bottom		available	available	available
Indicator	available	available	available	available

WRITE FOR BULLETIN 106

LOW PRESSURE VALVES CAN BE FURNISHED IN THE ABOVE TYPES, SIZES AND ACCESSORY EQUIPMENT. WRITE FOR DETAILS.

Est. 1877

THE KENNEDY VALVE MFG. CO. • ELMIRA, N.Y.

VALVES • PIPE FITTINGS • FIRE HYDRANTS

The Reading Meter

(Continued from page 48)

Selected Biological References Applicable to Water Treatment. *William M. Ingram. Ohio-Tennessee Drainage Basins Office, Div. of Water Pollution Control, U.S. Public Health Service, 1014 Broadway, Cincinnati 2, Ohio (1952) 35 pp.; paperbound; free*

This selected bibliography rounds out the subjects covered by two previous bibliographies—on sewage treatment and pollution control—prepared by the same agency and author (see August 1952 JOURNAL, P&R pp. 74, 76).

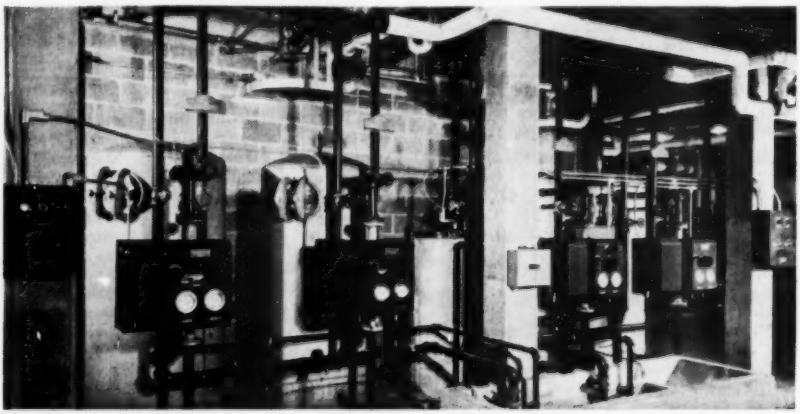
New Developments in Upright Sprinklers. *Norman J. Thompson. National Fire Protection Assn., 60 Batterymarch St., Boston, Mass. (1952) 18 pp.; paperbound; 50¢*

Improved spray distribution with a new sprinkler head is said to improve protection by making available water go further. The improved design is recommended either for new installations or as a replacement for existing installations where water supply is limited, or less than the fire hazard warrants. A reprint from the NFPA *Quarterly*.

The Industrial Utility of Public Water Supplies in the Pacific States, 1952. *E. W. Lohr, R. T. Kiser, C. S. Howard & I. W. Walling. Circular 232, Geological Survey, Washington 25, D.C. (1952) 89 pp.; paperbound; free*

Chemical analyses of raw and finished water, and background information on the water works, are provided for the major public water supplies in California, Oregon, and Washington. This is the fifth of a projected series of nine reports on the country's water supplies (see October 1952 JOURNAL, p. 92 P&R and December 1952, p. 20 P&R).

(Continued on page 52)



Automatic INVERSAND Water Softening & Acticar Taste and Odor Removal Plant—producing clear, 100% soft, palatable water.

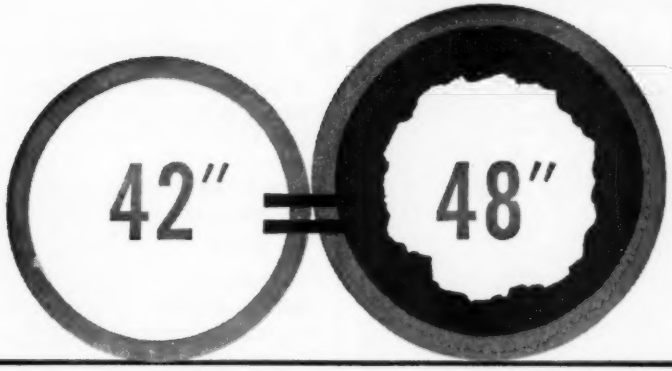
We build complete water treatment facilities, both large and small, for every need. Specialized treatment for local conditions, municipal and industrial, is our specialty.

Write for Bulletins that describe our water treatment plants.

H&T SERVICE

HUNGERFORD & TERRY, INC.

CLAYTON 5, NEW JERSEY



When 42" is as big as 48" you need... National

Yes, it's true!

Even a small amount of incrustation will reduce the carrying capacity of a 48" main to that of a clean 42" main.

The more your mains are clogged, the less capacity they have and the resulting reduced pressures increase pumping costs and fire hazard.

Take the easy way out—call National. Then, if your mains need cleaning we'll do the job quickly and effectively with little or no interruption in service.

Why not let our engineers find out what condition your water mains are in?

There's no obligation!

NATIONAL WATER MAIN CLEANING COMPANY
50 Church Street • New York, N. Y.

36

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by UNDERWRITERS' LABORATORIES, Inc.

GREENBERG
Independently Valved HYDRANTS
for non-freezing climates

Western water works engineers and fire chiefs were the first to approve Greenberg California-type fire hydrants. Now, after exhaustive tests, Underwriters' Laboratories, Inc. has confirmed your judgment.

Greenberg No. 74 and 76 hydrants are equipped with independent valves of a new type which open quickly and easily, allowing full flow with minimum resistance. They close tightly without water hammer. A major improvement over the old "cork in bottle" type valve!

Other innovations such as you would expect of the people who evolved the California-type hydrant 75 years ago are shown in the free booklet "Hydrants by Greenberg." May we send you a copy?

STABILITY since 1854

M. GREENBERG'S SONS
765 Folsom St • San Francisco • Calif • EXbrook 2-3143
Los Angeles • Seattle • Portland • Spokane • Salt Lake City • Denver • El Paso • New York • Hartford
Washington, D. C.

(Continued from page 50)

ALSO PUBLISHED

Fluoridation of Municipal Water Supply: A review of the scientific and legal aspects. *Charles S. Rhyne & Eugene F. Mullin Jr. Report No. 140, National Inst. of Municipal Law Officers, 730 Jackson Pl., N.W., Washington 6, D.C. (1952) $3*

Polarography. *I. M. Kolthoff & James J. Lingane. Vol. 1—Theoretical principles, instrumentation and technique. Vol. 2—Inorganic and organic polarography, biological applications, amperometric titrations. Interscience Publishers, New York (2nd ed., 1952) Vol. 1—438 pp.; $9. Vol. 2—568 pp.; $11*

The Effects of Community-wide Installation of Household Garbage-Grinders on Environmental Sanitation. *U.S. Public Health Service and Indiana State Board of Health. (1952) 20¢ from Supt. of Documents, Government Printing Office, Washington 25, D.C.*

Flow meters with even graduations are described in Catalog 2300 of the Minneapolis-Honeywell Regulator Co., Wayne & Windrim Ave., Philadelphia 44, Pa. A discussion of "flow cost accounting" is featured in the 28-p. booklet.

"Small Vertical Pumps" for sidewall or submerged mounting are described in an 8-p. bulletin, 52B6975A, being distributed by Allis-Chalmers Co., 1026 S. 70th St., Milwaukee, Wis.

A portable pH meter is the subject of Bul. 118 of Photovolt Corp., 95 Madison Ave., New York 16, N.Y. The Model 125 instrument is powered by three radio dry cells.

Plastic pipe for a variety of applications is the subject of a 16-p. catalog offered by the Plastics Products Div., Triangle Conduit & Cable Co., Inc., New Brunswick, N.J. Installation procedures for joining and use of fittings are included.

1879—ROSS—1879

Automatic Valves

ALTITUDE VALVE

Controls elevation of water in tanks, basins and reservoirs

1. Single Acting
2. Double Acting

Maintains safe operating pressures for conduits, distribution and pump discharge

SURGE-RELIEF VALVE

REDUCING VALVE

Maintains desired discharge pressure regardless of change in rate of flow

Regulates pressure in gravity and pump systems; between reservoirs and zones of different pressures, etc.

A self contained unit with three or more automatic controls

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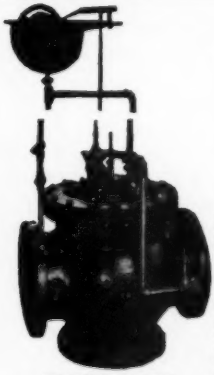

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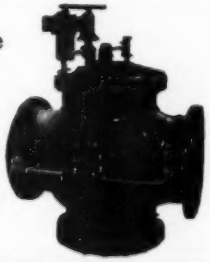

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Comeuppance!

To the Editor:

When "Abstracts" were dropped from the JOURNAL, on the grounds that the space could not be afforded, but "Percolation and Runoff" was squeezed in, I was much opposed to the idea of that change. Then "condensation" was introduced, which takes the place of "abstracts," and in the November issue these occupy about fourteen pages which I feel are well worthwhile and appropriate. However, after reading the eight pages of "Percolation and Runoff" in this same November issue, I feel impelled to suggest that a change of editorial policy with regard thereto is long overdue. Half the writings of the eight pages are either vacuous or funny-man stuff which would be more appropriate elsewhere—and don't think I don't enjoy *good comedy*.

Then, also, please refer to the first item at the top of Page 14 P&R. Is stating that this item is in very bad taste sufficient? I assure you I am not using the expression as a pun. The item is in far worse taste than the Philadelphia water used as the subject. Scurrilous remarks as here made on both Philadelphia and Cincinnati, do irreparable harm.

Unless the author is ignorant of events in this city so near to New York, he must know that conditions in Philadelphia are many times improved over past years, that water generally here is no worse than encountered frequently elsewhere by those who travel a bit. Today, outsiders as frequently state they find no objectionable taste as otherwise. This item is decidedly misleading.

Also, the article's inferences are a backhanded stab to those who have fought for several years to improve the situation, to improve the attitude of the public, and to improve the name of Philadelphia water. The author of "Percolation and Runoff" will be doing the Association a great favor by finding some other, worthwhile, outlet for his efforts.

E. L. BEAN

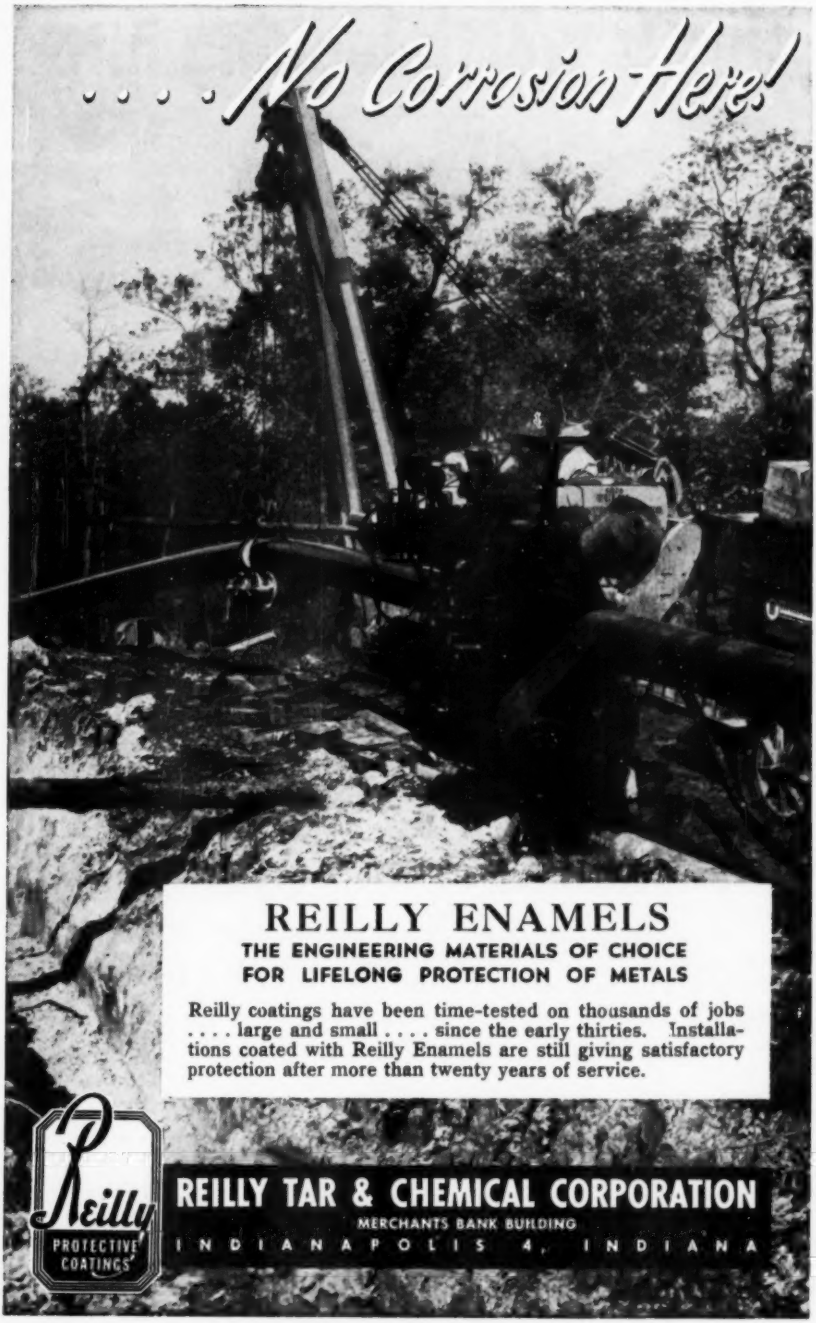
Philadelphia, Pa., Dec. 4, 1952

We can answer Mr. Bean's specific complaint with the assurance that no offense was intended to Philadelphia or to Cincinnati, though we'll not mention Moscow, from whence the "information" came. But the answer to the broader question he raises is for JOURNAL *readers to supply. Certainly if any number have been suffering in silence, the change is long past due. What's your pleasure?*—ED.

Flocculating equipment based on the "Walking Beam" principle is the subject of a 28-p. brochure issued by Stuart Corp., Baltimore 1, Md. In question-and-answer form, the booklet discusses the design of the mechanism, which features the use of above-water bearings, and includes photographs of actual installations.

Power plants constructed by the Dravo Corp. under the single-contract method are the subject of a 20-p. illustrated bulletin, No. 504, devoted to the activities of the firm's Power Dept. Boiler and power plants, pumping stations, water and sewage treatment systems are the department's special province.

A "Handy Guide to Selection of Centrifugal Pumps" may be had for the asking from Allis-Chalmers Mfg. Co., 1026 S. 70th St., Milwaukee, Wis. The 12-p. booklet is known as Bul. 52C6059J.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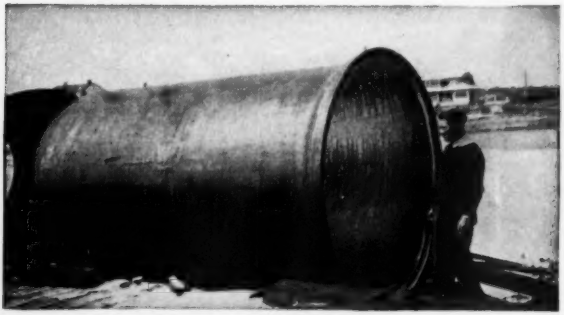

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Condensation

Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

SOFTENING AND IRON REMOVAL

Simple Method for Improving Rural Water Supplies. WODZIMIERZ SZYPOWSKI. Gaz, Woda i Techn. Sanit. (Pol.), **25**:273 (Sept. '51). Most rural water supplies are obtained from wells, a large percentage of which, exclusive of their unsanitary or structural states, provide waters which are hard or contain iron. The value of softened water has long been recognized by Americans, who in addn. to numerous central softening plants, had installed by 1947 approx. 370,000 household softening units. Discussion centers about removal of hardness, Fe, and Mn. For this purpose, two methods are available: [1] lime–soda ash for hardness removal; and [2] use of ion-exchange materials. The first method is not applicable to treatment of small supplies. Studies made of applicability of ion-exchange resins to treatment of rural water supplies. Several forms of ion-exchange materials considered: [1] inorganic zeolites; [2] organic carbonaceous zeolites, or synthetic phenolic and styrene-base resins. Removal of iron and manganese by ion exchange takes place readily if water is not aerated; these elements are in the Fe^{++} and Mn^{++} form, resp. Two exchange materials available for study: Permutit (probably an inorganic zeolite) and carbonaceous zeolite. Expt. set up as follows: 100 cu cm of each exchange material (grain size 0.5–1.0 mm) placed in tube having depth of 17.5 cm. Each column regenerated with 10% NaCl and washed with distd. water. Raw water having hardness of 13° (German scale) passed through column and samples taken every 500 ml for detn. of hardness (soap method). Columns continued in operation until effluent hardness reached 0.6° hardness from initial value of 0.3°. This corresponded to an exchange capac. for carbonaceous zeolite of 8 kg CaO per cubic meter and for Permutit zeolite 10 kg CaO per cubic meter. In similar manner, relationship between time of flow and degree of softening checked with bed depth and grain size. From curves presented for similar grain size and bed depth, time of flow and amount of softening are approx. the same. Using coarser grained materials, time of flow shorter, requiring greater depth to obtain same degree of softening. Optimum grain size appears to be approx. 0.5–1.0 mm. Using material of this size, approx. 90% of hardness could be removed with bed depth of 10 cm. In crude expt., perforated preserve can 10.5 cm in diam. containing 9 cm of carbonaceous zeolite fastened to discharge end of well pump. Raw water pumped through exchanger at rate of 2 l per minute. 80% hardness removal achieved. Unit could treat 30 l water contg. 25° hardness, and could be regenerated by immersion for 15 min in 10% soln. NaCl. Rinsed with 1.5 l water. Various other type containers used contg. 9 cm of resin. Raw-water hardness varied from 31.4 to 57° hardness; effluent hardness from 4.2 to 10.8° for a removal of 82–88%. Fe removal ranged from 67–80% for initial iron content of 0.5–6.0 ppm, and Mn removal from an initial content of 0–2.0 to 0–0.5 ppm. Suggested that units 20 cm in diam. and having a resin depth of 12 cm sufficient for treating 100 l of water having an initial hardness of 40°. Removals in excess of 90% expected at discharge rate of 6 l per minute. Use of method dependent on expansion of domestic (Polish) resin production. —*Conrad P. Straub*

Treatment of Cooling Water by the Phosphate Inoculation Process. Suitable Laboratory Apparatus. H. RUDY & K. R. MÜLLER. Chem. Ing. Tech., **21**:106 ('49). The author describes an apparatus and process designed to test the effect of addn. of small amts. of phosphate on the deposition of scale under conditions similar to those in cooling water. The results showed that

(*Continued on page 64*)

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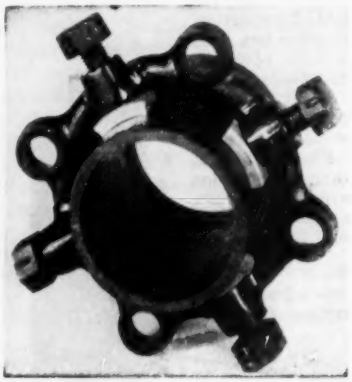
(Continued from page 62)

with increasing addn. (0.5–3 ppm) of sodium hexametaphosphate, deposition of scale became less and the final carbonate hardness increased. Higher addn. apparently caused no further improvement. Triphosphate had a similar but slightly less effective action. Pyrophosphate and orthophosphate were less effective. A combination of ortho- and metaphosphate was effective but was less effective than the equivalent amt. of hexametaphosphate. The small amt. of scale formed contains a comparatively high concn. of phosphate. Calcium carbonate separates mainly as sludge. Results are also given of some lab. expts. on the effect of organic materials—tannin, humic acid, sulfite waste waters—on the deposition of scale.—*WPA*

A Rational Method of Water Softening in Steam Boilers. V. Pospelov. Myasnaya i Molochnaya Prom. (U.S.S.R.), **13**:28 ('52). Nonchem. thermal water-softening process, elaborated by Golubtsov and Burkov, is described. It serves to reduce the scale formation from $CaSO_4$ by passing the intake through a hot zone within the steam space of the boiler; this effects pptn. of $CaSO_4$. The zone is also fed with some recycled boiler water to keep up the sulfate ion concn. to facilitate the pptn. The effluent from the hot zone passes through a settling reservoir and the supernatant fluid goes to the boiler proper. Several typical designs are shown. —*CA*

Natural and Synthetic Agents for the Removal of Aggressive Carbon Dioxide From Water. Jan Just & Jadwiga Kelus. Gaz, Woda i Techn. Sanit. (Pol.), **25**:289 (Oct. '51). Experiments described in which imported and domestic materials were evaluated for removal of CO_2 from water. Materials used included Swiss product Magno II, Kielce gray marble, white marble, natural dolomite ($MgCO_3 \cdot CaCO_3$) (Dolomite II), and Dolomite II heated to 400°C for 4 hr. Each of these materials placed in a glass column filter and various waters passed

(Continued on page 66)



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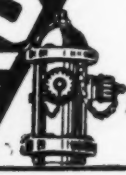

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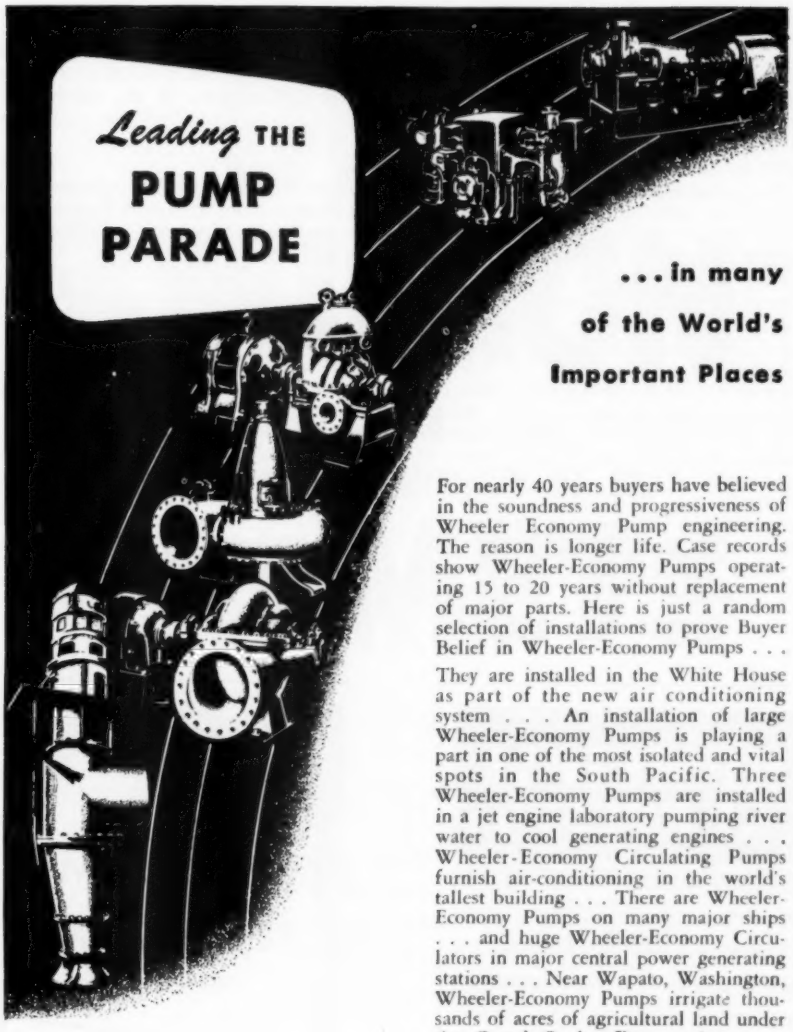

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(Continued from page 64)

through the columns and their effect on removal of CO_2 noted. Using Magno II, complete removal of CO_2 obtained even at high rates of flow. At lower rates of flow, almost complete removal of Fe and Mn obtained; at rates of 6 cu m per square meter per hour, good removals occurred. Remaining materials gave following results on waters high in CO_2: using Kielce gray marble, removals of aggressive CO_2 ranged from 33 to 50%, white marble 34 to 86%, natural dolomite 8.2 to 46.9%, Dolomite II (heated to 400°C for 4 hr) 32.9 to 80.4%. Lower figures correspond to the higher rate of flow of 2 cu m per square meter. On low CO_2 waters at 2 cu m per square meter flow rate removals of aggressive CO_2 were: Magno 100%; Kielce gray marble 20%; and natural dolomite (Dolomite II) 80%.—*Conrad P. Straub*

Increasing the Efficiency of Cationic Filters. E. I. POLUKAROVA. Izvest. VTI (U.S.S.R.), **21**:22 ('52). Design and mech. improvements of water-softening filters are described. By virtue of these improvements the exchange capac. of the cationite rose from 500–600 to 800–900° per cubic meter. —*CA*

Processes in Hydrogen Exchange Filters and Research on Hydrogen Exchange Filters in the Laboratory. J. LEICK. Vom Wasser (Ger.), **18**:380 ('50–'51). Calculation and methods of operating cation-exchange resins in the H cycle are discussed for industrial use and for lab. research. Three basic methods are described for ion exchange on the H cycle: [1] begin the operation of deionizing with the filtrate having a residual hardness less than that of the combined mineral acid content of the raw H_2O and ending with an increase of alky. in the filtrate; [2] begin the deionization with the filtrate having a residual hardness under 0.1° (1 German degree = 1 part CaO per 100,000 parts of H_2O) and ending with a residual hardness over 0.1°; [3] begin the

(Continued on page 68)

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(Continued from page 66)

operation with an acid value of the filtrate equal to the mineral acid content of the raw H_2O and ending with an acid value smaller than the mineral acid content. Data are given for the regeneration of Group A resins, sulfonate type resins, and Group B resins, carboxylic type resins, with strong acids. Residual hardness, distribution of ions in the exhausted filter bed, and specific acid consumption (HCl) are given for raw water softened according to the three methods. Regeneration with H_2SO_4 is compared with the HCl and was found to be less efficient than the HCl. Formulas and discussion are given for the calcn. of bed depths, bed vols., the effect of Na in the influent, and the buffer action of various ions. Specifications and datum format are given for the lab. research of these exchange resins.—*CA*

Demineralization Builds Up an Excellent Operating Record. M. E. BRINES. Power, **96**:94, 206 ('52). Both cation and anion exchangers are described. Deaeration is also part of the treatment. This treatment, however, does not always remove insol. colloidal silica, although anal. of the finished water does not show its presence. Operating procedure is described in detail. Charts and tables are included.—*CA*

Dow's Demineralizing Experience. M. E. BRINES. Power Eng., **56**:82, 114 ('52). Diagrams and cuts help explain the operating procedure in Dow's Midland, Mich., plant where combined cation and anion exchangers are in use.—*CA*

WELLS AND GROUND WATER

Geology and Ground Water Resources of the Kansas River Valley Between Lawrence and Topeka, Kansas. STANLEY N. DAVIS & W. A. CARLSON. State Geol. Surv. Kansas Bul. No. **96**:201 ('52). This survey includes analyses of 24 samples of waters, mostly moderately hard calcium bicarbonate waters.—*CA*

(Continued on page 70)

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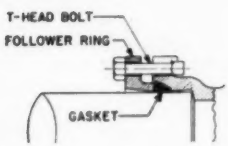

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(Continued from page 68)

Geology and Ground Water Resources of Lane County, Kansas. GLENN C. PRESCOTT JR. State Geol. Survey Kansas Bul. No. 93 ('51). This study includes anals. of 31 waters, mostly rather hard calcium bicarbonate waters. The F content was high; 20 samples contained 1–5 ppm of F; three others contained 6, 6, and 8 ppm of F.—*CA*

Ground Water Resources of Pawnee Valley, Kansas. V. C. FISHEL. State Geol. Surv. Kansas Bul. No. 94 ('52). This survey includes anals. of 70 samples, mostly moderately hard calcium bicarbonate waters. —*CA*

Geology and Ground Water in the Charlotte Area, North Carolina. H. E. LEGRAND & M. J. MUNDORFF. N.C. Dept. Cons. & Devel., Div. Mineral Resources Bul. No. 63 ('52). This survey includes anals. of 49 water samples from seven counties. Waters derived from granitic rocks are normally low in dissolved matter; those from dioritic rocks are higher in dissolved matter but are satisfactory for most uses.—*CA*

Ground Water in the Vicinity of Trinidad, Colorado. W. J. POWELL. Colorado Wtr. Cons. Board, Ground Water Serv. Circ. No. 3:1 ('52). Analyses of nine waters are included, most of which are very hard. Some contain much $CaSO_4$.—*CA*

Ground Water Resources in the Vicinity of Kenmore Farms, Kendall County, Texas. W. O. GEORGE & W. W. DOYEL. Tex. Board Wtr. Engrs., Bul. No. 5204 ('52). The aquifer is a limestone. Seven anals. of calcium bicarbonate waters are given.—*CA*

The Hydrochemistry of Ground and Well Waters in the Northern Rhineland. MARGARETA KELLER-HAFFENNEGGER & REINER KELLER. Forsch. Deut. Landeskunde (Ger.), 50:1 ('51). Regional variations in hardness, Fe, and Mn content are given in the form of a map based on the avg. of thousands of anals. of the waters of the region.—*CA*

Using Radioactive Isotope to Trace Movement of Underground Water. CYRIL S. Fox. Munic. Util., 90:30 (Apr. '52). Watertightness of proposed reservoir site to remove menace of flooding of Nile R. in Egypt investigated. Several questions on direct leakage into Faiyum basin, losses down mineralized fault fissures, and absorption into strata forming floor of natural basin. First two questions studied by infiltration from boreholes, but percolation problem more difficult. "Catchment area" (almost rainless region) 400 sq miles with max. depth 300′ (nearly 200′ below sea level). When filled to depth of 100′ above sea level, lake will have waterspread of nearly 300 sq miles. Annual loss by evapn. 6–9′. There are damp sands in deepest point of basin, and brine occurs in sands at shallow depths. Except for rare runoff rain and five low-mound springs of seeping brine, only source of replenishment for brine in sands three fresh-water springs with total discharge of not more than 10 gpm, which disappears into sand within a few yards. Nearest spring approx. 7 miles from deepest part of basin. Evidence suggests floor must be watertight. Confirmed by adding 10% soln. radioactive rubidium chloride (half-life 19 days) to spring water at point of disappearance and detecting residual radioactivity in brine in sands 5 days later with "water moni-

(Continued on page 72)

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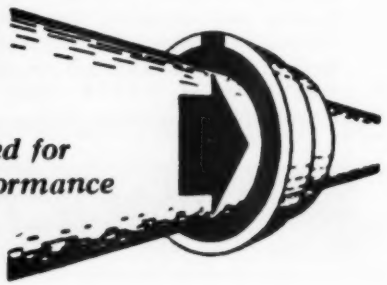

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B-I-F INDUSTRIES — A CENTURY OF QUALITY 1853 — BUILDERS

(Continued from page 70)

tor." Brine was more radioactive than 1: 1,000,000 dilution of original 10% soln.—*R. E. Thompson*

CANADIAN WATER SUPPLIES—GENERAL

Montreal Water Works Expands on Par With City's Growing Population. Eng. Cont. Rec., **65**:132 (May '52). Montreal system supplies Montreal, Outremont, Westmount, and other municipalities; total pop. served 1,454,000. Per capita consumption 119 gpd. Avg. consumption 128 mgd in '40, 169 in '50. Items in '45 expansion program completed include new 300-mgd intake of 4'–7' prestressed concrete pipe extending 2,000' into St. Lawrence R., which has improved raw water quality; addnl. battery of 16 rapid sand filters, increasing filter capac. from 150 to 200 mgd; conversion of old slow sand filters into 15-mil gal storage reservoir; new high- and low-lift pumps; enlargement of McTavish pumping station to accommodate 3 new 30-mgd centrifugal pumps; and new transmission mains. Pump discharge valves and station outlet valves are spherical, the first such valves in Canada. Contemplated are: enlargement of filtration works to 300 mgd; new 35-mil gal reservoir; and addnl. high-lift pumps, service reservoirs, and trunk mains.—*R. E. Thompson*

Continued Development in Winnipeg Water Works. P. A. Rowe. Eng. Cont. Rec., **65**:107 (May '52). A 20-yr, $10,000,000 plan of improvement includes: [1] constr. before '63 of second alkali-resisting, lock-joint concrete aqueduct from Shoal Lake by Greater Winnipeg Water Dist. at estd. cost $5,340,000; [2] erection of 80-mil gal reservoir and pumping station in South Winnipeg, 1960–65, by city, at estd. cost $1,322,500; [3] feeder mains at estd. cost $3,997,859, to be constructed from $200,000 appropriation each year for 10 yr and $300,000 for succeeding 10 yr. The estd. pop. of city in '70, 270,000, increase 32,000; of district, 440,000,

(Continued on page 74)

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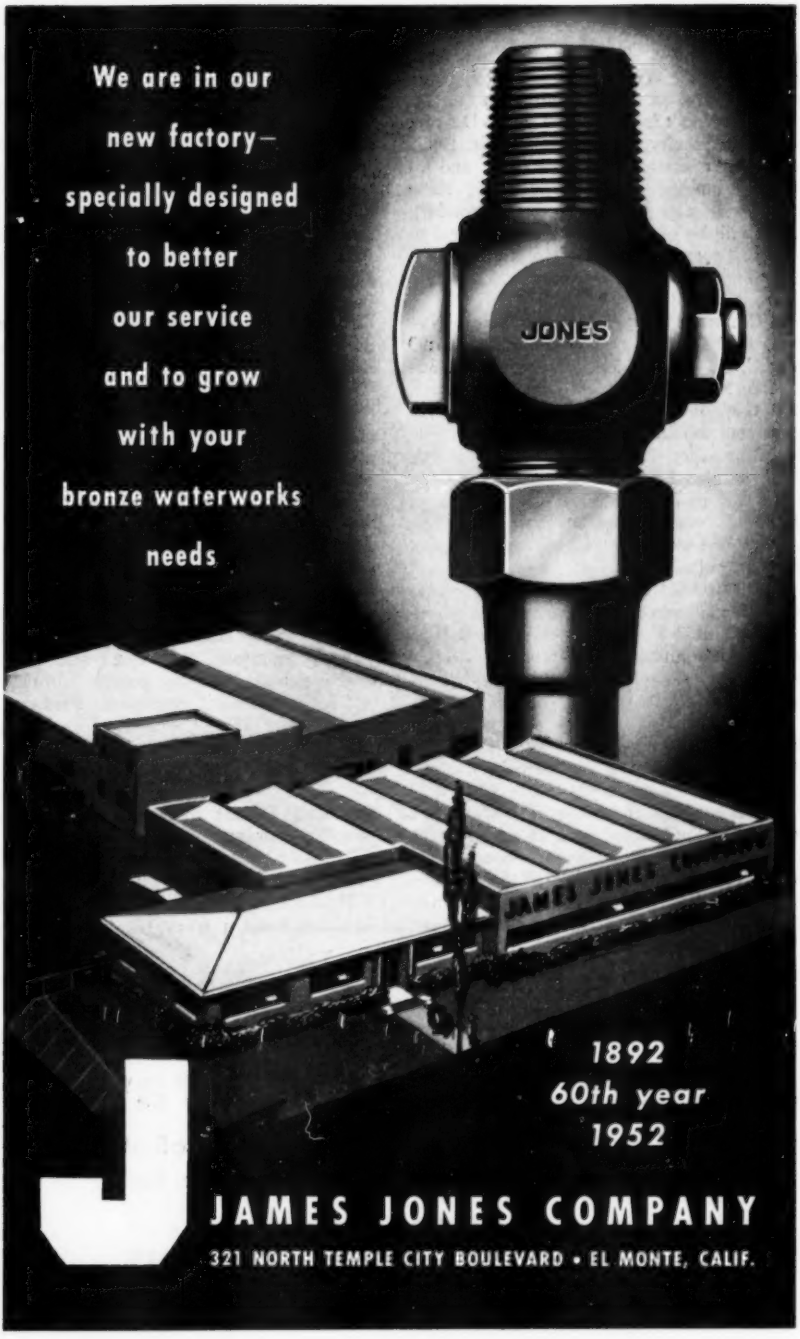
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(Continued from page 72)

increase of 77,000. The estd. avg. and max. consumption by Winnipeg and municipalities served by city, 35 and 48 mgd, resp., in '70. Present aqueduct from Shoal Lake to Deacon, 13 miles from city, 85 mgd, but to St. Boniface booster station only 50 mgd, and to North Winnipeg reservoir 40 mgd; these capacs. will serve only until '63. Secondary mains will be of asbestos cement, found to resist soil corrosion and electrolytic action.—*R. E. Thompson*

New Concrete Supply Main to Bring Water to Old Quebec. Eng. Cont. Rec., **65**:90 (Mar. '52). New 7.5-mile precast line, 36–48″ diam., chiefly 42″, from Lake St. Charles, more than 100′ above highest city el, will supplement existing 40″ c-i. line and provide 200 psi pressure where it joins distr. system. Ditch excavated to an avg. depth of 12′ between two rows steel piles, 10–14″ base of reinforced concrete poured in two courses, and pipe laid and anchored by rod type steel straps to bolts set in top course. Expected piles will be used three times before replacement. Avg. cover 6–8′ well below usual frost limit of 3–5′. At two river crossings, both new line and old line (formerly carried on steel bridges) will be placed under water. Estd. cost $3,500,000.—*R. E. Thompson*

Renfrew's (Ontario) New Water Supply System Meets Needs of Town's Expansion. E. M. Proctor. Munic. Util., **90**:25 (Mar. '52). Pop. in excess of 7,000. New filter plant constructed at cost of $300,000. Bonnecherè R. source of supply since approx. 1900. New works include 16″ c-i. intake, self-washing traveling screen, two elec. 1-mgd vertical centrifugal low-lift pumps, alum, carbon, and lime dry feeders, flash mixing basin, flocculators, clarifier (2.5 hr detention), two rapid sand filters (total capac. 1.15 mgd) contg. 14″ graded gravel and 24″ sand over Miller block bottom and equipped with Palmer agitators, 0.5-mil gal filtered water reservoir, and two elec. 1-mgd high-lift pumps. Alum and carbon fed before and lime and chlorine subsequent to filtration. Standby pumps, low- and high-lift, driven by diesel engines.—*R. E. Thompson*

Drummondville's (Quebec) New Water Supply System Provides for City's Rapid Expansion. Louis Crepeau. Munic. Util., **90**:21 (May '52). Pop. increased 400% in 20 yr. New 3-mgd filter plant, adjoining but operated independently of older 1.5-mgd plant, consists of 30″ concrete intake pipe in St. Francis R., two low-lift horizontal centrifugal pumps, one driven by elec. motor and other by gasoline engine, dry feeders for alum and lime, 30-min mixing basin, two coagulation basins providing 4 hr retention, four 0.75-mgd rapid sand filters contg. 18″ graded gravel and 27″ sand overlying perforated brass laterals and equipped with Palmer agitators, and elec. and gasoline engine-driven high-lift pumps. Both pre- and postchlorination employed. Pressure 100 psi normally, 125 psi for fire. Fire insurance rates among lowest in province.—*R. E. Thompson*

Canada's Oldest Water Supply System. W. R. Godfrey. Munic. Util., **88**:22, 32 ('50). An historical acct. is given of the public water supply system of St. John, N.B., since its inception in 1838. Water was originally drawn from Lily Lake, but this

(Continued on page 76)

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(Continued from page 74)

source proved inadequate in quality and quantity, and an impounding reservoir was constructed on Little R. At present the section of the city on the west bank of the St. John R. obtains water from Spruce Lake; this supply can be supplemented by 2 mgd from underground sources. East St. John is supplied by water from Loch Lomond. It is felt that most intestinal bacteria perish before reaching the intakes. The only treatment given to both supplies is chlorination. Both waters are very soft; water from Loch Lomond has a hardness of 15 ppm and water from Spruce lake 10 ppm. Together they supply 25 mgd to a pop. of 80,000.—*WPA*

Calgary's (Alberta) Water Supply and Its Operating Problems. W. E. Robinson. Munic. Util., **88**:25, 40 ('50). The Glenmore water works at Calgary was designed to treat 28 mgd of water but with the rapid growth in pop. and increase in consumption of water per head, problems in the supply and distr. of water have arisen. During 1934–49 the pop. increased from 85,000 to 110,000 and the avg. consumption increased from 16.4 to 23.7 mgd, with a peak consumption of 50 mgd in June. To increase supplies, the height of the dam has been raised and the capac. of the sand filters has been increased to 38 mgd by more efficient operation. To reduce consumption, measures are being taken to prevent leakage from pipes and reservoirs.—*WPA*

New All-welded Steel Standpipe at St. Foy, Quebec, Has Million Gallon Capacity. E. Nesbitt. Eng. Cont. Rec., **64**:84 (Nov. '51). New standpipe, 96′ high and 46′ in diam., has reinforced concrete foundation and dome roof and is provided with cathodic rust prevention system. Nine electrodes, 90′ long, suspended from spokelike framework under roof. Steel plates vary in thickness from 1″ at bottom to ¼″ at top of tank. Pressure maintained in mains 40–90 psi as required. Continuous pumping no longer necessary.—*R. E. Thompson*

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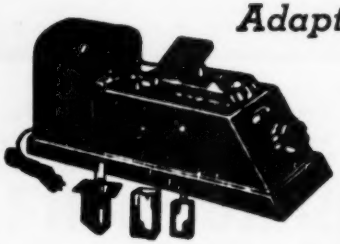

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Section Meetings

Wisconsin Section: The Wisconsin Section held its thirty-first annual meeting in Madison at the Hotel Loraine on September 16–18, 1952. For the second consecutive year a new attendance record was made, as a total of 314 persons registered.

The Fuller Award Committee reported no award for the current year. The Section voted to confer a Citation of Appreciation, however, on a "true friend of the Wisconsin Section and a loyal promoter of membership in the American Water Works Association—Francis Cunningham."

As is usual with the Wisconsin Section, the program was divided into four sessions—Surface Water, Ground Water, Distribution and Pumping, and General —with half a day devoted to each. Each session was opened by a movie and included two prepared papers and a panel discussion.

The Surface Water Session, held on Tuesday afternoon, September 16, opened with Chairman Edward F. Tanghe presiding. Mayor George Forster, of Madison, welcomed the group and discussed the businesslike functioning of the Madison Water Dept. The Chairman then spoke briefly of the present economic situation and the value of meetings of this kind, enabling water works operators to keep abreast of the times. After the report of the Secretary-Treasurer, Leon A. Smith, the meeting was turned over to Bruno J. Hartman, Chairman of the Surface Water Session. A paper was presented on "Water Levels of the Great Lakes," prepared by Col. Kumpe of the U.S. Army Engineers and presented by George Wesler.

E. F. Bean, state geologist of Madison, next presented a paper on "Surface Waters in Wisconsin." In the panel discussion which followed, W. U. Gallaher of Appleton briefly discussed the treatment of the Appleton surface water supply, George Steinmetz of the Wisconsin Public Service Commission talked on some of the commission's responsibilities for water supplies, H. J. Draves of Michigan City, Ind., talked on the effect of high lake levels on his filtration plant. Harvey Wirth, assistant state sanitary engineer, discussed briefly the possibility of recharging the underground water supply in the Milwaukee area. Harry Jordan called attention to the fact that this was quite a common procedure in certain areas in California and on Long Island.

On Tuesday evening an informal lunch and entertainment were held.

Vice-Chairman William F. Leistikow presided at the Ground Water Session on Wednesday morning, and gave a brief account of the three gravel-wall wells which Wausau recently put in operation.

A movie entitled "Waters of the Commonwealth" was shown. This picture, in color and sound, was furnished by the Standard Oil Co. William A. McEllhiney presented a paper on "The Construction and Development of Deep Wells in Wisconsin." H. S. Merz gave an interesting talk on "Drilling Wells in the Glacial Drift at Rockford, Ill." Joseph Lustig, city engineer of Janesville, reported on gravel wall wells in his area. Eugene R. Kelly, district engineer of the State Board of Health at Rhinelander, related his experience in trying live steam and other unconventional methods for rehabilitating gravel wall wells.

(Continued on page 80)

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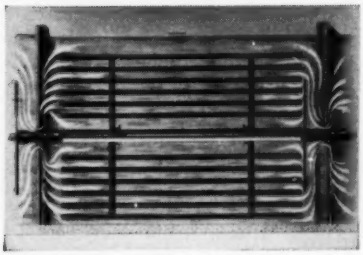

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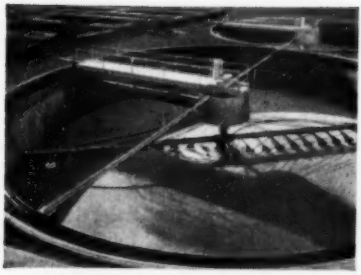

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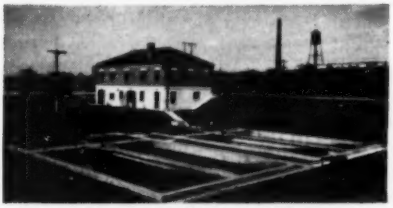

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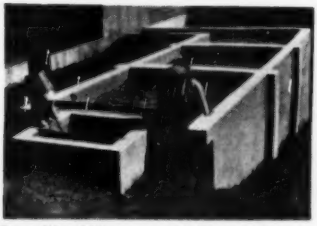

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SANITATION EQUIPMENT

Section Meetings

(Continued from page 78)

A luncheon was held Wednesday noon at which AWWA Secretary Jordan discussed the expensive changes required in distribution systems by highway programs, and he recommended that the members of the section assemble records of these costs so that they could be cited when the federal government is asked to include them in federal highway construction costs. Harold Londo of Green Bay was selected chairman of the committee to assemble this information.

Chairman Hubert J. Evers presided at the Distribution and Pumping Session held Wednesday afternoon, after a movie, "The Manufacture of Cast-Iron Pressure Pipe," had been shown by the Cast Iron Pipe Research Assn. Two papers were presented—one on "Automatic Controls" by J. S. Williams of the Automatic Control Co., and the other, "Red Water and Its Prevention," by Philip S. Davy, consulting engineer of La Crosse. A panel discussion which followed included the two speakers, together with Harvey E. Wirth of the State Board of Health and E. Tournow of the Appleton Water Dept.

The banquet was held Wednesday evening, September 17. Leon Smith was honored for his 25 years as secretary of the Wisconsin Section—the longest record of service in this capacity in the AWWA. Walter Peirce, manager of the Racine Water Dept., spoke on behalf of the water works operators and Carl Brown, president of the manufacturers association, spoke on behalf of the manufacturers. Secretary Smith was presented with a very fine television set, complete with radio and record player. Many telegrams and letters of congratulation were received, some of which were read at the banquet. In addition, Secretary Jordan presented an AWWA Life Membership certificate to Secretary Smith in recognition of his continuous membership since 1916, a period of over 30 years. Similar certificates were presented to Ed Brown of Eau Claire and Walter Peirce. An excellent floor show followed.

The final session was held Thursday morning, and Zenno A. Gorder presided over this last General Session. A movie, "1951 Big Ten Grid Highlights" was shown to start the program. It was well received and interested many members attending. The first paper, "Management of Municipal Water Utilities," was presented by John C. Doerfer, chairman of the State Public Service Commission. The second paper, "Water Main Extension Records," was presented by O. P. Deuel, also of the Public Service Commission of Wisconsin. The third paper, "Artificial Rainmaking," by V. E. Soumi, chairman of the Dept. of Meteorology at the Univ. of Wisconsin, dealt with a topic of current interest, and was entertaining as well as enlightening.

The panel discussion which followed was led by John C. Doerfer, O. P. Deuel, P. A. Reynolds, rate analyst, and Arthur P. Kuranz, superintendent of the Waukesha water utility.

State Chairman Edward F. Tanghe closed the session, expressing thanks to the committees responsible for the success of the entire meeting and to the various speakers, and introduced the 1952 Chairman-Elect, William F. Leistikow, superintendent of the Wausau Water Works, to the members.

LEON A. SMITH
Secretary-Treasurer

North Carolina Section: The thirty-second annual joint meeting of the AWWA North Carolina Section and the North Carolina Sewage & Industrial Wastes Assn. was held at the Skyland Hotel in Hendersonville on November 10–12, 1952. The natural beauties of the city, located in the Blue Ridge Mountains, together with the well-planned entertainment by the host city, helped to make it a well-attended and successful meeting. The total registration of 261, including 37 ladies, exceeded all previous registrations, except for the years 1928 and 1929.

The meeting was officially opened on

(Continued on page 82)

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"Southern's" new exterior cement mortar coating process offers many new values. Typical of these is the unvarying control of the mortar's water content. This factor assures high early set and resistance to fracture. Greater density and exact thickness tolerances are also achieved through minimizing of rebound.

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Section Meetings

(Continued from page 80)

Monday morning with Chairman Davis presiding. The invocation, given by Rev. James P. Burke, was followed by a cordial address of welcome by Mayor A. V. Edwards of Hendersonville. The technical session was begun by W. F. Stokes, superintendent of the Hendersonville Board of Water Commissioners, who presented an interesting paper entitled "Hendersonville Water Works." This was followed by a talk on the subject "Fluoridation Practices" by Walter M. Franklin, superintendent of the Water & Sewage Dept., Charlotte, N.C.

The honorary luncheon for national officers and guests featured an address by Charles H. Capen, AWWA President, and E. Sherman Chase, FSIWA President. The luncheon was followed by a very interesting joint water and sewage works discussion panel during which short talks were given on the subjects "Modern Instruments as Aids to Water Plant Operation," "Use of Meter Master in Winston-Salem," "Home-Made Alarms and Controls," "Selection and Use of Protective Coatings," "Sewer Use Ordinance," and "The Maintenance of Sewage Collection Systems." All of these talks were interestingly presented and encouraged considerable discussion from the floor.

The Tuesday morning session was opened with a paper entitled "Maintenance and Repairs to Cathodic Protection Systems," by F. J. LeFebvre of Electro Rust-Proofing Corp., Belleville, N.J., which was discussed by Herbert F. Finck, power and hydraulic engineer, Ecusta Paper Corp., Pisgah Forest. The remainder of the morning program was devoted to the general theme of "Meeting the Needs of North Carolina's Industrial and Community Growth." The subjects and speakers were: "Forecasting North Carolina's Industrial and Community Growth," by Brandon P. Hodges, state treasurer; "Planning Water and Sewage Facilities for Future Growth," by H. E. Beckwith, Pitometer Co., and P. D. Davis, Piatt & Davis, consulting engineers; and "A Proposal for Solving Water and Sewage Needs for Suburban Areas," by Jackson T. Ramseur, Gaston County health officer, and W. N. Long, chief sanitary engineer, Gaston County Health Dept.

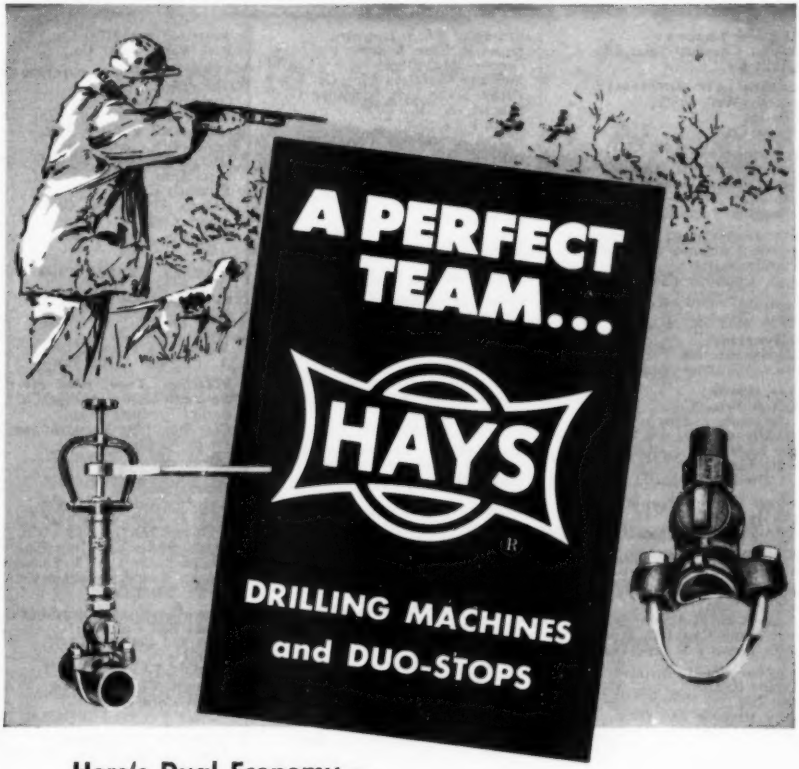
Tuesday afternoon was devoted to an inspection trip to the Ecusta Paper Corp. plant at Pisgah Forest.

The Annual Banquet took place on Tuesday evening with an attendance of 217 members and guests. The George Warren Fuller Memorial Award was presented to the committee's 1952 nominee—H. F. Davis, who is district manager of Wallace and Tiernan Co., Inc., Charlotte, N.C., and Section Chairman for 1952—by AWWA President Charles H. Capen. The Maffitt Membership Cup was awarded to Harry J. Siebert of Charlotte, for obtaining the greatest number of new members for the section. The address of the evening was delivered by Alan Newcombe of Greenville, S.C.

The Wednesday morning program was devoted to a discussion of previous technical papers and a most interesting paper entitled "The Use of Tonnage Oxygen in Sewage Treatment," presented by Dan Okun, associate professor of sanitary engineering at the School of Public Health, Univ. of North Carolina. The close of the technical session was followed by the annual business meeting, at which new officers were elected and committee reports were presented.

Social events, aside from the annual banquet and dance, included a barbecue dinner and entertainment featuring the Echo Inn Clog Team, given by the Hendersonville Board of Water Commissioners and Chamber of Commerce. A luncheon for the ladies at the Elks Club was followed by a tour of localities and club room entertainment provided by the manufacturers. These activities were splendidly handled by the Local Arrangements Committee and Club Room Committee and proved most enjoyable.

E. C. HUBBARD
Secretary-Treasurer



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(See Prof. Services, pp. 25-29)

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Wallace & Tiernan Co., Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.
Worthington Pump & Mach. Corp.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valve-Inserting Machines:
A. P. Smith Mfg. Co.

Valves, Altitude:
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
James B. Clow & Sons
Crane Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Belco Industrial Equipment Div.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Crane Co.
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing
Dearborn Chemical Co.
Inertol Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Water Treatment Plants:
Allis-Chalmers Mfg. Co.
American Well Works
Belco Industrial Equipment Div.
Chain Belt Co.
Chicago Bridge & Iron Co.
Dearborn Chemical Co.
Dorr Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.
Worthington Pump & Mach. Corp.

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
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Zeolite; see Ion Exchange Materials

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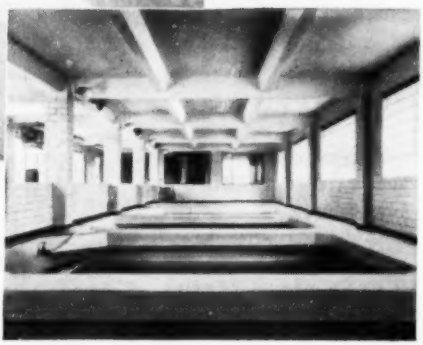

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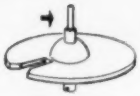

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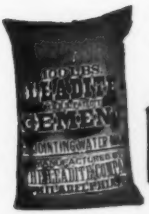

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